MODELLING THE LOSS OF SOILS, ATRAZINE AND PHOSPHORUS IN A SOUTHWESTERN ONTARIO AGRICULTURAL WATERSHED

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Watershed Management Section
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1.0 SUMMARY

Beak Consultants Limited (BEAK) has completed a three year field study and modelling program to examine soil, phosphorus and atrazine transport from agricultural fields in Southwestern Ontario. The Ontario Ministry of the Environment (MOE) contributed site specific field studies on the decay of atrazine and farm operator surveys of atrazine useage. Analytical services were provided by MOE, Rexdale and the Ontario Ministry of Agriculture and Food (OMAF), Pesticide Residue Laboratory, Guelph.

The Nissouri Creek Watershed, a 31 km^2 agricultural watershed in Oxford County within the Lake Erie drainage basin, was chosen as the subject area for this study. The scope of the study was comprehensive and included a field monitoring program, modelling, a demonstration of conservation farming system analysis, and an examination of transport/transformation processes.

Soil loss and hydrology were investigated as well as the migration of phosphorus and atrazine, a commonly used herbicide, from the Nissouri Creek Watershed. This report discusses methods employed and results obtained in meeting the specific objectives of the program which include the following:

- establish a comprehensive watershed database for examining causal relationships in land management,
- examine and quantify soil, plant nutrient (phosphorus) and pesticide (atrazine) transport/transformation processes in an agricultural setting,
- calibrate the watershed model HSPF in the Ontario agricultural environment,
- demonstrate the modelling approach to land management, and
- demonstrate the potential benefit of selected conservation practices.

The field study components include watershed instrumentation and monitoring for hydrology (streamflow), surface and sub-surface water quality, meteorology (6 parameters), soil and stream sediment characteristics, farm management practices, atrazine decay and atrazine use. Laboratory measurements of atrazine adsorption rates were also conducted. The watershed model HSPF (hydrologic simulation program - FORTRAN) was calibrated and verified for the prediction of runoff, soil loss, and phosphorus and atrazine transport from the land to the receiving waters. The results of calibration at several sites for these 4 parameters are presented. The usefulness of HSPF for predicting the benefit of soil conservation practices was demonstrated.

Atrazine was selected for examination in this study because it is commonly used, it is relatively persistent, and it has been observed to move from treated fields to streams. Atrazine is currently the most commonly used herbicide in Ontario (McGee, 1984) and is used mainly for weed control in corn fields. It frequently persists from one season to the next in treated fields at typical levels of about 10% of that applied. Atrazine is a member of the triazine group of herbicides which were the most commonly detected pesticides in surface waters in Ontario from 1979 to 1985 (from MOE monitoring networks data, personal communication with Dr. Lloyd Logan).

The study area is typical of a large portion of the Southwestern Ontario farming region in terms of farming systems (conventional mixed cash cropping and livestock production), soil types (silty loams), topography (gently rolling) and socio-economic characteristics. Atrazine use is widespread for the control of annual broadleaf and grassey weeds in the corn fields of the Nissouri Creek Watershed.

The Nissouri Creek Watershed was one of eleven specially selected agricultural watersheds studied as part of the PLUARG program (Pollution from Land Use Activities Reference Group). PLUARG provided detailed study area information including soil characteristics, agricultural practices, hydrology, and watercourse loadings of soil, nutrients and pesticides. This information was invaluable in this study as it provided historical perspective and some of the key modelling inputs.

In developing a comprehensive database for the Nissouri Creek Watershed, four continuous automatic streamflow stations were installed at the watershed outlet and at strategic headwater sites. Drainage areas monitored in this manner ranged from 1.6 to

31 km^2. Automatic surface water quality samplers were installed at each of these sites and were operated in a manner which allowed for the collection of flow proportional composite samples. Groundwater piezometers were installed at three depths at three sites for collection of groundwater quality samples and measurement of the groundwater levels.

The meteorological network included one main installation which continuously recorded six climate parameters. Parameters measured at this site included rate of rainfall, wind speed and direction, solar radiation, air temperature, and evaporation. In addition, two other recording rain gauges and five standard rain gauges were strategically located around the watershed.

Soil and sediment parameters were also measured at various locations in the study area.

The field monitoring program continued from June 1984 until December 1986. Thus, the watershed database covers two complete hydrologic years as required for model calibration and verification. Several extreme runoff events and extended dry periods occurred during this time period and have been "captured" in the watershed data set. The results of field monitoring are provided in the form of summaries and time series files in this report.

Land use was determined from aerial photography and ground truthing. In addition, the land owners were surveyed in 1985 and 1986 regarding their use of pesticide and crop selection by MOE staff. Land use and pesticide use was found to differ significantly from one year to the next.

Field level studies of pesticide behaviour and persistence in the soil matrix were conducted on selected field plots in 1985 and 1986 by MOE. In these studies, precise measurements were made of pesticide application rates over a well defined field plot (10 x 50 m). Surface and sub-surface soil samples were taken from this plot frequently and at regular intervals for up to eleven months following application. The total mass of atrazine in the soil matrix was estimated for each sample period and subsequently, overall decay rates were determined. These decay rates were used to estimate model parameters which relate to pesticide decay and transport. Observed trends were used to compare with predicted trends as a form of model verification.

HSPF is a U.S. EPA model which has been in development since the late 1950's. It began as the Stanford Watershed Model and has since been expanded to include a comprehensive list of capabilities and water quality parameters. The model is a dynamic, lumped parameter model which requires descriptive geo-based information on a watershed's soils, topography, drainage system and land use. The model requires that the subject area be discretized into several pervious and impervious areas which are internally homogeneous in all relevant aspects. The model simulates overland runoff and chemical washoff as well as stream routing of flow and all simulated constituents. The model simulates the continuous response of the watershed to meteorological events and conditions and considers the special actions of farm operators upon the movement of water, soil and chemicals. The model operates on a short time step (i.e., minutes to hours) over long periods of time (i.e., up to several years). Structured programming allows for considerable input and output data management.

HSPF was calibrated for the Nissouri Creek Watershed with the 1985 database. Verification was conducted using the 1986 database. Hydrologic verification was successful both in terms of the simulation results for the total annual and monthly water balances, as well as the simulation results for individual events. Total soil loss, and phosphorus and atrazine transport were also successfully calibrated and verified for the study period. Most events and long-term simulations are within 10% of the observed runoff rates.

HSPF simulation results provide some insight into the behaviour of the hydrologic cycle as well as the primary factors influencing soil loss and phosphorus and atrazine movement. Surface overland runoff was predicted to be a relatively rare event. It was predicted that spring snowmelt and eight major warm weather storms generated 95% of all surface runoff in 1985 and 1986. The high density of sub-surface drainage in the Nissouri Creek Watershed was shown to be effective in rapidly draining surface soils and allowing more water to pass through the sub-surface drain system. Antecedent conditions which determine the surface soil water content were highly important in the partitioning of precipitation runoff between surface and sub-surface pathways.

Soil erosion and the washoff of soil attached phosphorus and atrazine was shown to be highly event based. About 80% of all soil loss and 85% and 65% of phosphorus and atrazine losses respectively from 1985 and 1986 were predicted to occur as a result of snowmelt runoff and the eight major storms. These accelerated runoff periods accounted for only 30% of all measured precipitation.

Sub-surface flow pathways including tile drainage and groundwater runoff were shown to be significant pathways for phosphorus and atrazine movement as 14% of phosphorus and 57% of atrazine were predicted to enter the watercourse in baseflow.

Total runoff of water, soil, and phosphorus were predicted to occur predominantly during snowmelt periods and during wet periods in the spring and fall. These were the periods when most of the surface overland runoff occurred. Almost all of the soil and soil attached phosphorus moved with surface overland runoff. About 59% of the phosphorus losses were predicted to be sediment associated while an additional 34% of the total phosphorus export was predicted to be surface washoff in a soluble form.

Atrazine is relatively soluble in water and a large portion of the atrazine that was lost was predicted to pass down through the soil matrix to the tile drainage system. About 47% of the total atrazine export was predicted to pass into the watercourse from tile drains. Less than 10% of the total atrazine export was predicted to be from the groundwater and only 1.3% was predicted to be surface washoff in a soil attached form. The remaining 42% of total atrazine export was predicted to be surface washoff in a soluble form. These results were partially verified by stream water analysis during runoff events which showed that more than 95% of all atrazine was in the aqueous (soluble) phase. Total atrazine losses amounted to only 3.3% and 0.84% of that which was applied over the entire watershed in 1985 and 1986 respectively. The majority of atrazine decayed within the soil matrix by volatilization, biochemical decay, plant uptake and photochemical breakdown.

Because of the high solubility of atrazine and its low affinity for soils, its movement was less event oriented than phosphorus and soil. The majority of atrazine movement occurred during the summer months and in the early autumn when atrazine use is most active. However, a residual amount of the atrazine remains in the soil over the winter and is subject to spring washoff during snowmelt periods. About 9.5% of the total predicted atrazine loss occurred during the 1985 and 1986 snowmelt periods.

One of the primary objectives of this study was to demonstrate the ability and usefulness of the modelling approach in land management planning. A set of six conservation farming schemes were selected and relevant model parameters and special actions were programmed in HSPF to reflect the unique characteristics of each. Guidance in adjusting model parameters was provided from U.S. EPA field and modelling studies, especially the HSPF demonstration on Iowa's Four Mile Creek agricultural watershed. Unfortunately, the exact degree of parameter adjustment for each conservation scheme is not well established and therefore considerable uncertainty exists at this stage. Also, relatively little knowledge exists for the Ontario setting in this respect. The model application to assess the benefit of various conservation farming schemes is meant as a demonstration of the ability of HSPF to reflect sensitivity and change to farming practice. The model predictions presented in this report should not be taken as quantitative evaluations but rather as qualitative assessments which are more suitable as relative indications of potential benfit.

Two non-structural measures were evaluated with HSPF including a no-tillage system and contour strip cropping. Two structural measures including tile drainage and retention basins were also evaluated along with two operational management schemes including the optimized timing of planting, and chemical application; and sub-surface incorporation of applied chemicals. These systems were selected for this demonstration because, as a group, they represent a wide spectrum of possible systems and therefore provide a rigorous test of model capabilities and sensitivities. These systems are also commonly considered in conservation planning and therefore represent workable possibilities.

The no till and strip contour management systems were found to be relatively effective in reducing soil loss and phosphorus loss by reducing surface overland runoff, providing more protective plant cover during the vulnerable spring and fall periods and by reducing the disruptive effect of plowing. These methods were only marginally effective in reducing atrazine loss since atrazine largely partitions towards the sub-surface drainage system in the Nissouri Creek Watershed. These methods are promising and practical and should be considered as viable options in any conservation plan.

More complete tile drainage in the Nissouri Creek Watershed was predicted to reduce soil, phosphorus and atrazine loss by reducing surface runoff. While predicted improvements in this case were significant, it is one of the most difficult to accurately simulate, and somewhat impractical in terms of agricultural return on investment.

The retention basin option was shown to be potentially effective in trapping soil already in the watercourse but was relatively ineffective in reducing phosphorus and atrazine losses due to their large soluble (i.e., non-settleable) components. This option is somewhat impractical as it has high initial capital costs as well as continuing maintenance costs. Furthermore, trapped soil must be returned to the erosion prone areas from the retention basins in order to optimize the benefit. This method does nothing to alleviate the problem at the source and should be considered only when water quality remediation is required.

The optimized application of phosphorus fertilizer and atrazine to avoid periods of high potential runoff was predicted to be ineffective in reducing phosphorus loss since it does nothing to reduce the vulnerability of phosphorus on the soil to potential surface washoff. Atrazine loss reduction is predicted to be significant with this scheme because it allows time for the atrazine to leach from the surface into the soil matrix prior to surface washoff events. This scheme is less applicable in areas that do not have reliable five day weather forecasts but is promising in that it requires no investment or drastic changes in farming practice.

The incorporation of phosphorus fertilizer and atrazine beneath the soil surface on application was found to be marginally effective in reducing the losses of these materials for a short period following application. This scheme does nothing to reduce the portion of phosphorus and atrazine which move through the surface soils into the tile drains in the Nissouri Creek Watershed. Incorporation is likely to be more effective in reducing losses of pesticides which are strongly soil bound and which are therefore more susceptible to surface washoff than is atrazine.

The analysis of benefit discussed in this report showed that HSPF can reflect changes in farm management systems as it allows for alterations in parameters which affect all relevant aspects of the watershed system. That is, it explicitly accommodates changes in all components of the hydrologic cycle, the chemical storage compartments and the chemical transformation/transport algorithms. As HSPF is comprehensive in its description of processes, it is sensitive to farming systems which affect those processes.

Further research is necessary to define the effects of various conservation practices on transport and transformation processes in the Ontario agricultural setting. This research must generate a more complete matrix of runoff parameters for various management options upon a variety of Ontario soil types and landscapes. This information is essential before land management models will be capable of predicting benefit in quantitative terms.

Recommendations have been presented for conducting future studies and modelling of agricultural runoff and land management. Firstly, it is recommended that watershed studies continue as the most effective means of quantifying agricultural land processes. More specifically, monitoring of streamflow and water quality should continue on the Nissouri Creek Watershed. This basin has an excellent database at present covering about five years from 1976 to 1986 with much time series information on water quality, hydrology and meteorology. It is representative of a much larger area in Ontario and can serve as a bench mark to change in terms of land management and its long term effect on erosion and chemical transport. Watershed studies should extend over several years in order that the effects of meteorologically abnormal years can be minimized and so that a good perspective on long term processes can be obtained.

It is recommended that future studies address sub-surface runoff as an important contributor to the total of watershed runoff processes. While surface overland runoff accounts for effectively all of the soil erosion in a system it is not the only route by which agricultural fertilizers and pesticides move into the watercourse as evidenced by the results of this study.

Evapotranspiration is a major component of the hydrologic cycle. This parameter should be measured more directly if possible in order that a true water balance can be achieved in watershed studies.

Field and plot level studies should be included in watershed investigations. This level of examination allows for more conclusive observation regarding the casual relationships between runoff and tillage practices. It also allows for low risk experimentation involving tillage practices, chemical useage, and cropping systems.

Farm operator cooperation is a necessary component of any agricultural runoff program. It is recommended that at the onset of any study of this nature, that an agreement between the farm operators and the researchers be established. This agreement may include monetary compensation for incurred costs, inconvenience, time required to provide information, and risk insurance against loss of productivity. This type of approach can result in a mutually beneficial experience, which for the researcher, can include access to detailed farm operation information which would be otherwise unavailable.

The majority of soil and soil attached chemicals are transported from watersheds during snowmelt periods and extreme storm events. Field studies should be designed to intensify the event based information. While considerable runoff of soluble material can occur during extended baseflow periods, the runoff of the particulate portion of these materials is a rare event which is often limited to less than 5% of the time.

It is recommended that farming systems which reduce surface runoff and leave protective cover on the ground over the fall, winter and early spring periods be promoted. These systems can be very effective at reducing soil and chemical loss while improving productivity at little or no cost to the farmer. In fact, in many cases there is a short and long term financial benefit to the farmer with these systems. Modelling indicates that it is during the rare but extreme event that most of the soil and chemical loss occurs. Conservation schemes must take this into account and protect soil against high intensity rainfall and snowmelt by identifying the problem areas and by providing cover protection and runoff alleviation in those areas during the normally vulnerable periods.

Finally, it is recommended that HSPF be adopted as the primary tool for detailed, quantitative research and assessment of conservation land management plans and for extrapolation of watershed results to a regional scale. HSPF provides the hydrologic and transport framework upon which new information can be built. It recognizes the complexity of the watershed runoff system and applies an appropriate level of descriptive detail in simulating it. HSPF requires no more or less input information than that which is necessary in any research or assessment study. It provides the necessary interpolation between observations while aiding in the determination of material balances necessary for long term simulation.

2.0 INTRODUCTION

2.1 Background

Non-point source pollution has been recognized as a serious and growing problem in recent years. Several river basin studies have revealed that the balance between point and non-point sources of pollutants entering our receiving waters is shifting to the less controllable, non-point sources. When erosion is left unchecked, agriculture suffers from the loss of valuable organic topsoil and soil nutrients while the local receiving water becomes choked with silt and enriched with plant nutrients. Agricultural chemicals used for pest control have also been detected frequently in streams, occasionally at high levels, since their use became widespread in the 1970's.

At the same time that problems which accompany advancing technology have been detected and monitored, our understanding of hydrologic and physical/chemical processes has expanded. In the 1980's we are at a stage of model development and in possession of an experience base and sufficient computing power to allow for detailed quantitative assessments of diffuse source problems. These assessments can include the evaluation of advanced management practices designed to reverse the trends of non-point source pollution.

Three universal problems which result from the superposition of man's agricultural activity on nature's hydrologic cycle are:

- accelerated soil loss resulting from the clearing of vegetative areas and the disturbance of surface soils.
- the transport of plant nutrients (phosphorus and nitrogen) with soil and in soluble forms to streams and lakes where they cause eutrophication.
- the transport of pesticides from agricultural fields to receiving waters and possible toxic contamination of endemic organisms and humans.

Soil transport by storm runoff results in the movement of valuable topsoil from places where it is most productive to places where it has little or no productive value or to streams where it causes siltation. Siltation, in turn, destroys fish spawning areas and causes infilling of reservoirs and navagable waterways. Erosion is so serious that certain susceptible agricultural fields in Ontario will be completely stripped of topsoil in a few decades if conservation practices are not implemented.

Plant nutrients applied in the form of fertilizers are largely bio-available to algae in streams and lakes. The impact of relatively uncontrolled fertilizer runoff with eroding soil and percolating sub-surface runoff to the Great Lakes, reservoirs and rivers has been observed. This problem is manifested in the form of algal blooms, the replacement of pristene cold water aquatic communities with low diversity warm water communities, the loss of recreational resources, and many other perceptible and insidious repercussions (Goldman et al., 1986). Figures 2.1 and 2.2 are unit area loading maps for sediment and phosphorous respectively for all of Southern Ontario (PLUARG, 1978d). These maps highlight the extent and magnitude of the problem and the need for remedial measures to control runoff and erosion in the agricultural regions of Southwestern Ontario.

Pesticide use has grown dramatically since World War II and has been responsible for improvements in agricultural productivity and efficiency for the following reasons, (Hileman, 1982):

- better crops due to lack of competition by weeds and attack by other pests; and
- no till systems can be used along with pesticides since tillage for weed removal is unnecessary. No till systems result in lower fuel and labour costs, reduce erosion and speed up cropping and conversion to other crops.

However, several disadvantages of pesticides have been reported:

- possible weed resistance and substitution of other nuisance species;
- possible increased insect activity and insecticide requirements in absence of weeds;
- soil pesticide carryover to the following year may necessitate the abandonment of crop rotation. This inevitably leads to deterioration of soils and possible development of pesticide resistance by weeds and insects;

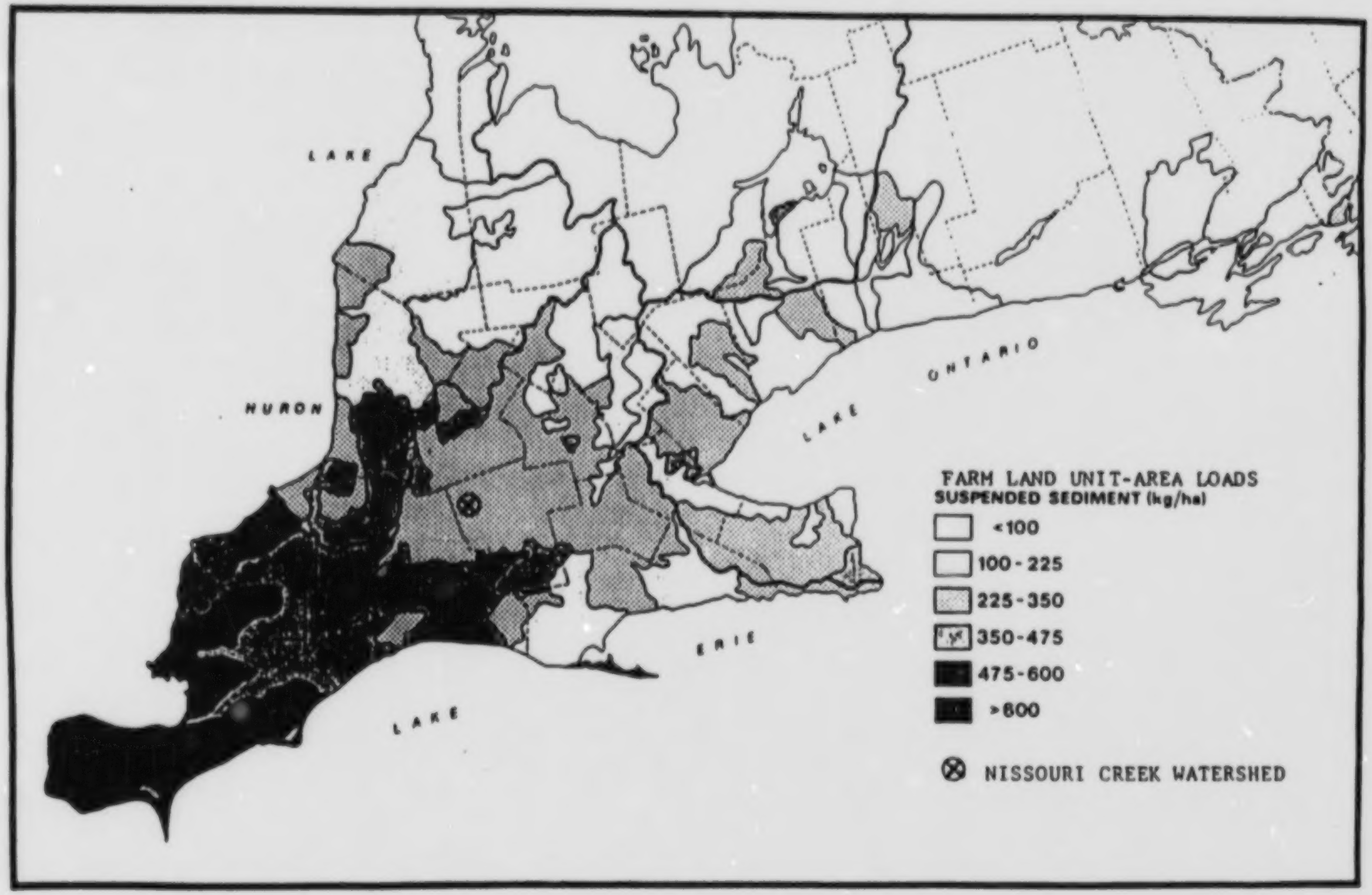

LAKE
HURON
LAKE
ONTARIO
LAKE
ERIE
FARM LAND UNIT-AREA LOADS
SUSPENDED SEDIMENT (kg/ha)
<100
100-225
225-350
350-475
475-600
>600
⊗ NISSOURI CREEK WATERSHED

Figure 2.1 : Predicted Unit-area Loads of Sediment from Each Unit-area of Farm Land in the Watershed Sub-Basins of the Agricultural Portion of the Canadian Great Lakes Basin (after PLUARG,1978d)

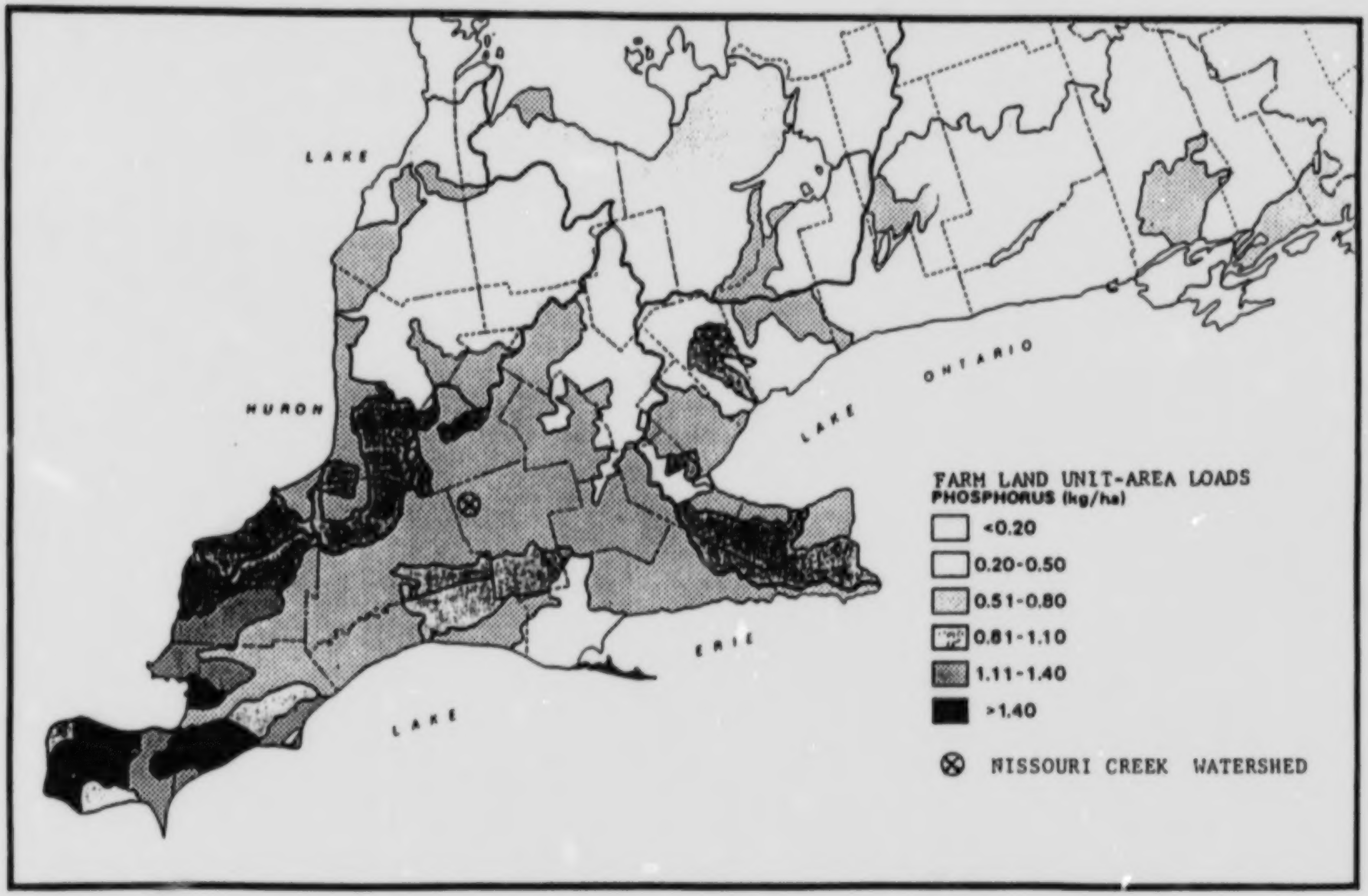

LAKE HURON
LAKE ONTARIO
LAKE ERIE
FARM LAND UNIT-AREA LOADS
PHOSPHORUS (kg/ha)
<0.20
0.20-0.50
0.51-0.80
0.81-1.10
1.11-1.40
>1.40
⊗ NISSOURI CREEK WATERSHED

Figure 2.2 : Predicted Unit-Area Loads of Total Phosphorus from Each Unit-Area of Farm Land in the Watershed Sub-Basins of the Agricultural Portion of the Canadian Great Lakes Basin (after PLUARG, 1978d)

- synergistic effects of various pesticides on non-target organisms; and
- the introduction of pesticide contaminants (ie. dioxin in 2,4,5-T and silvex) into the environment and subsequent toxic effects to man and aquatic organisms.

The incidence and persistence of pesticides and their byproducts in the environment are increasing rapidly. Figure 2.3 shows the measured concentrations of atrazine and its metabolite in three agricultural watersheds studied as part of PLUARG including the Nissouri Creek Watershed (PLUARG, 1978b). These streams were observed to be contaminated at measurable levels at all times and in some seasons they were heavily contaminated by a variety of pesticides.

Atrazine (2 chloro-4-ethylamino-6-isopropylamino-5-triazine) is currently the most widely applied herbicide in Ontario (McGee, 1984). It is a member of the triazine group and is most commonly used in mixtures with other herbicides for weed control in corn crops. It is applied in the spring in pre-planting, pre-emergent or post-emergent forms and/or in the fall for over winter weed control. It is moderately soluble in water (33 mg/L at 25°C) and has a low vapour pressure (3×10^{-7} mm Hg at 20°C).

Now that pesticides have become an important aspect of crop production there may be no easy way to eliminate their use. Organic farming and genetic engineering offer some future possibilities. However, the approach to the reduction of negative impacts must also pursue the development of safe chemicals (if possible) and in keeping the chemicals where they are intended. This study is directed towards the latter approach.

Conventional agricultural practices employed in a high production mode can result in serious degradation of the lands capability to produce as well as significant environmental contamination. Agricultural practices which attempt to reduce the negative impacts of agriculture on the land and the streams are termed "Best Management Practices" (BMP's) and are effective to various degrees at reducing environmental impacts while keeping the soil, nutrients and chemicals in the fields. Concern has been expressed by the farming community about the cost of various BMP's in terms of increased operating costs and reduced crop production. It is therefore necessary to investigate the advantages, disadvantages and costs of each practice and then to develop farm plans which optimize production and conservation in a cost effective manner.

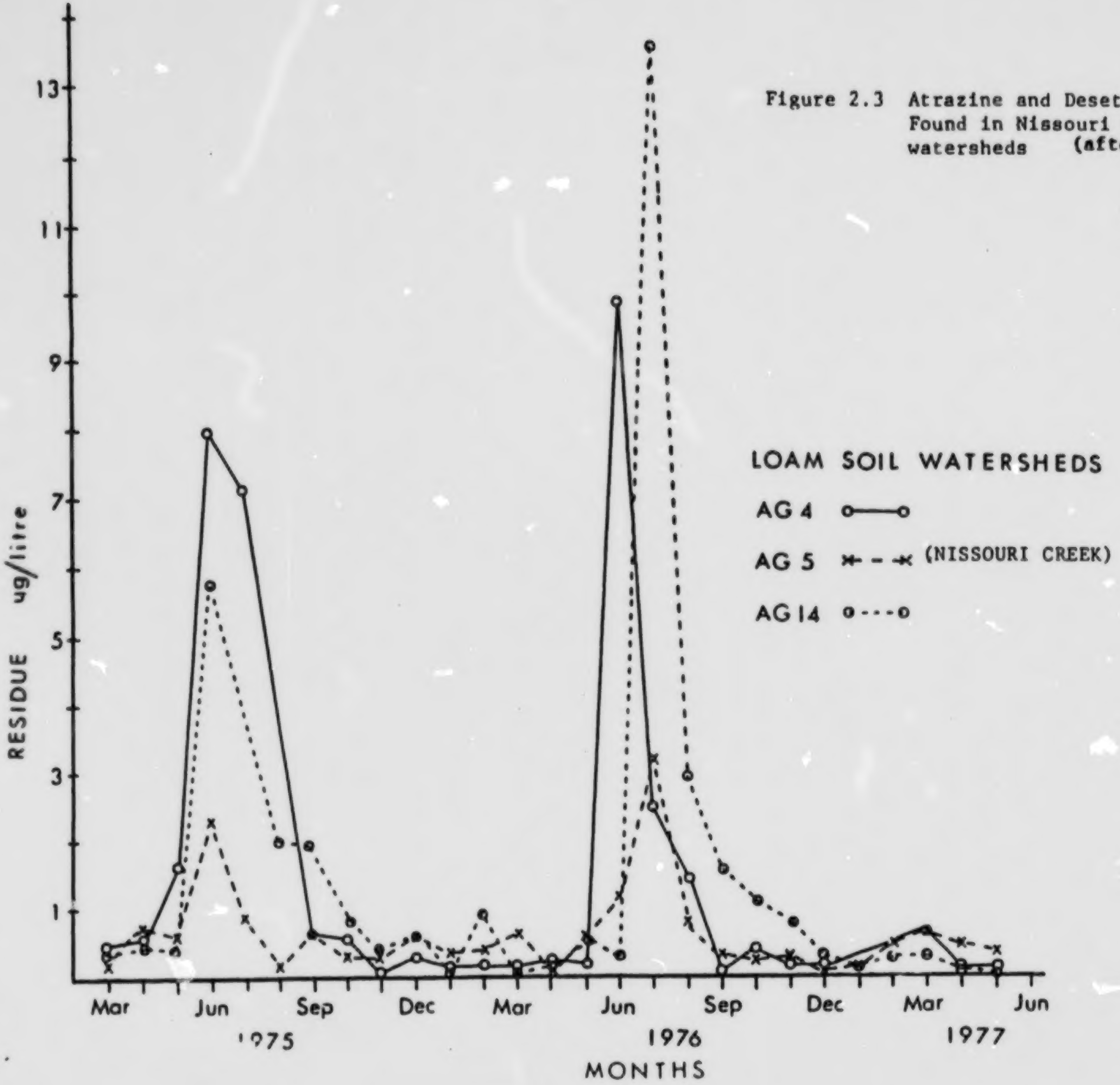


Figure 2.3 Atrazine and Desethyl Atrazine Found in Nissouri Creek and two other watersheds (after PLUARG, 1978b)

Table 2.1 CAPABILITIES OF OPERATIONAL WATER QUALITY RUNOFF MODELS (Huber and Heaney, 1980)

MODEL NAME	PROBLEM CHARACTERISTICS																																		
	Applicable Land Area				Temporal Properties			Spatial Prop.		Hydrology				Hydraulics				Quality Processes									Residuals								
	Urban	Agriculture	Forests	Wetlands	Single Storm Events	Continuous Simulation	Annual or Seasonal Average	Single Catchment	Multiple Catchments	Surface/Total Hydrograph Generation	Subsurface Processes	Snowmelt	Dry-weather/Base Flow	Flow Routing in Channels/Pipes	Backwater, Surcharging, Pressure Flow	Flow Controls and Diversions	Storage/Reservoir Routing	Surface Generation	Routing in Channels/Pipes	Sediment/Erosion	Scour/Deposition in Channels/Pipes	Parameter Interaction	Soil/Sediment-Parameter Interaction	Routing through Storages	Treatment/Removal in Storages	Treatment Processes	Organics/BOD/COD	Nitrogen Species	Phosphorus	Suspended Solids	Coliforms	Pesticides	Arbitrary or other Conservative	Arbitrary or other Non-Conservative	Economic Analysis
HYDROSCIENCE	*						*	*		*								*						*		*	*	*	*	*	*		*		
MRI	*		*				*	*										*		*			*				*	*	*	*	*	*	*	*	
SWMM-Level 1	*						*	*		*			*					*									*	*	*	*					*
FPARRB	*	*	*	*	*		*	*										*		*							*	*	*				*		
Simpl.SWMM	*					*			*	*							*									*	*	*	*		*				
ACTMO		*				*			*	*	*	*						*		*	*		*					*	*			*	*	*	
ARM		*			*	*		*		*	*	*						*		*		*	*			*		*	*	*		*	*	*	
HSP	*	*	*		*	*			*	*	*	*	*	*		*	*	*	*	*				*			*	*	*	*			*		
NPS	*	*	*	*	*	*			*	*	*	*						*		*			*				*						*		
QQS	*				*	*			*	*			*	*	*	*	*	*	*							*							*		
STORM	*					*		*		*		*	*				*	*		*						*	*	*	*	*	*				
AGRUN		*							*	*	*			*				*	*	*							*			*	*		*		
CAREDAS	*								*	*			*	*	*	*	*		*					*									*	*	
SWMM	*					*			*	*		*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*		*		*
CREAMS		*				*		*		*				*			*	*	*	*	*	*	*	*	*			*	*	*		*			

Table 2.2 CAPABILITIES OF OPERATIONAL RECEIVING WATER QUALITY MODELS (Hinson and Basta, 1979)

MODEL	WATER BODY CHARAC.										MAJOR PROBLEMS																									
	Water Body Type					Flow Conditions					Temp.			Salinity				Erosion & Sed.			Dissolved Oxygen				Eutro-phicat.			Toxic Subst.				Biological Effects				
	Streams	Rivers	Lakes	Estuaries	Offshore Waters	Constant Streamflow	Variable Streamflow	Tidal Action	Steady State Lake Levels	Variable Lake Levels	Ambient Variations	Waste Heat Inputs	Thermal Stratification	Natural Salt Sources	Irrigation Return Flows	Saltwater Intrusion	Salinity Stratification	Bedload Transport	Suspended Solids Transport	Absorbed Residuals Transport	COD-Nonpoint Sources	COD-Point Sources	Nitrogenous Oxygen Demand	Instream Oxygen Demand	Nitrogen Kinetics	Phosphorus Kinetics	Minor Nutrients	Heavy Metals	Pesticides	Refractory & Synthetic Organics	Radioactive Material	Decomposers inc. Coliforms	Primary Producers	Zooplankton-Invertebrates	Fishes	Ecosystems-Level Indicators
SSM	•	•	•			•															•	•														
SEM		•		•		•										•					•	•														
DOSAG-1	•	•				•															•	•	•													
DOSAG-3	•	•				•								•	•						•	•	•		•	•		•				•	•			
DOSCI	•	•				•								•	•						•	•	•		•	•		•				•	•			
ES001				•		•		•								•					•	•		•								•	•			
QUAL-1	•	•				•															•	•	•									•				
DEM	•	•		•		•	•	•			•	•				•			•	•	•	•	•		•	•	•	•	•	●	●	•	•			
TTM	•	•		•		•	•	•			•	•				•																				
RECEIV	•	•	•	•		•	•	•	•	•						•					•	•	•		•	•	•	•	•	•	•	•				
RIVSCI	•	•		•		•	•	•			•	•				•					•	•	•		•	•	•	•	•			•	•			
WRECEV	•	•		•		•	•	•								•					•	•	•		•	•	•	•	•	●	●	•				
DRM			•			•	•		•	•	•		•																							
LAKSCI			•			•			•				•			•					•	•	•					•								
EPARES			•			•	•		•	•	•	•	•	•	•	•	•				•	•	•		•	•	•	•				•	•			
HSP	•	•	•			•	•		•	•	•	•	•								•	•	•	•	•	•		•	•	●	●	•	•	•		
CAFE/DISPER		•	•	•	•		•	•											○						○	○	○	○	○	○	○	○	○	○	○	
EXPLORE-1		•		•		•		•								•			•		•	•	•	•	•	•		•		•		•	•			
PLUME			•	•	•																	•														
HYD/SAL				•	•	•		•								•																				
QUAL-II	•	•				•					•	•		•	•				•		•	•	•		•	•		•	•	●	●	•	•			
LAKECO			•			•	•		•	•	•	•	•								•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
ECOMOD				•		•	•	•								•			•	•	•	•	•	•	•	•	•					•	•	•	•	
ESTECO				•	•	•	•	•								•				•	•	•	•	•	•	•	•					•	•	•	•	•
LAKE-[illegible]			•						•				•												•	•							•	•	•	
WQRRS	•	•	•			•	•		•	•	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•					•	•	•	•	
Narragansett Bay Model				•	•	•	•	•			•					•					•	•	•		•	•							•	•	•	
HSPF	•	•	•			•	•		•	•	•	•		•	•			•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•		

• applicable

○ applicable if treated as discrete particles

● applicable if treated as conservative constituent

Abbreviations: inc., in

The only effective way to evaluate BMP's on a large scale is to use hydrologic-diffuse source models. These tools integrate the effects of land management and agricultural activities on runoff and storage in the watershed system and allow for the prediction of future site specific conditions.

Land management models have been the subject of considerable development and testing during the past 20 years. Initially, hydrologic models were developed as event based predictors of hydrologic processes. The Stanford Watershed Model (Crawford and Linsley, 1966) was used as a basis upon which Negev (1967) superimposed sheet and gully erosion equations as well as instream sediment transport. A lumped parameter model, PTR (pesticide transport and runoff), was later developed by Crawford and Donigian (1973). This model "piggybacked" applied pesticide onto the hydrologic and sediment transport components of the evolving Stanford Watershed Model. This approach emphasized the need for transport mechanisms of watershed hydrology as a basis for agri-chemical behaviour simulation. The PTR model included hydrologic simulation, sediment detachment and erosion, pesticide adsorption/desorption, vertical movement of pesticide in the soil, and pesticide degradation.

Further modification and testing of the PTR model resulted in the agricultural runoff management (ARM) model (Donigian and Crawford, 1976b; Donigian et al., 1977). This model simulates runoff including snow accumulation and melting, sediment loss, pesticide-soil interactions, and soil nutrient transformations. Further developments to ARM added components of soil moisture and temperature, pesticide degradation, nutrient transformations, and plant nutrient uptake. The ARM model was fully supported by a users manual and was the first practical and widely operational predecessor of HSPF.

A simpler version of ARM was developed which could be used with current urban models such as SWMM, (storm water management model) (Metcalf and Eddy et al., 1971) and STORM (storage, treatment, overflow, runoff model, U.S. Army Corp. of Engineers, 1975 and Huber et al., 1975). The resulting model, NPS (non-point source model, Donigian and Crawford, 1976a and b) was a continuous simulation model which improved the snow handling and sediment transport components of urban runoff models.

HSPF (Johanson et al., 1980) is the most recent and comprehensive model in this series. This model incorporates time series data management systems, recognizing the enormous task of input and simulation data handling. Channel routing is linked to land surface runoff modules and a simple sediment routing algorithm has been added. Water quality algorithms added include BOD/DO dynamics, carbon, nitrogen and phosphorus cycles, and suspended and attached phytoplankton and zooplankton. The most recent version of HSPF, release 8.0 (Johanson et al., 1984), has included a chemical migration and risk assessment methodology (Onishi et al., 1979). This methodology includes sediment transport by particle size groups, pesticide routing and degradation kinetics, sediment-pesticide interaction, a frequency analysis summary of contaminant concentration, and toxicant risk assessment.

HSPF is a dynamic watershed hydrologic and water quality model which requires dynamic time series inputs of weather and management practices as well as descriptive characteristics of the watersheds soils, topography, drainage and agricultural practices. The model simulates the processes which result from precipitation on the watershed in terms of runoff and associated water quality parameter movement and behaviour. The surface runoff and sub-surface seepage is then routed to the watershed streams where it is subject to instream transport and transformation processes.

The model is built upon a systematic framework in which a series of application modules are used to perform various hydrologic and water quality processes; and utility modules are used to perform various data management functions. Application modules include:

- PERLND, the pervious land segment module;

- IMPLND, the impervious land segment module, and

- RCHRES, the receiving water module.

Utility data management modules include the following:

- COPY, a module for manipulating, aggregating or factoring a time series of data;

- PLTGEN, the module which creates specifically formatted files for plotting;

- DISPLY, the module which summarizes data and presents it in neatly formatted tables;

- DURANL, a module which performs a duration and excursion analysis; and

- GENER, a module which can perform a number of basic tranformations of one or two time series.

HSPF is a hybrid model which has benefited in its development from several other models (i.e., ARM, NPS, HSP, PTR, Stanford Watershed Model etc.) and at this stage, represents the current 'state-of-the-art' in continuous simulation of non-point source material. Other models have been developed with different approaches and are useful in more specific ways. Tables 2.1 and 2.2 were extracted from a report by Donigian (1981) which lists currently available water quality runoff models and receiving water quality models and their capabilities. Models such as CREAMS (chemicals, runoff and erosion from agricultural management systems) (Crowder et al., 1985), STORM and SWMM are continuous simulation models which have received widespread use and testing in Canada and the United States.

Another class of model which has seen widespread use is the distributed parameter land management model. These models were built upon the work of Meyer and Wischmeier (1969) to predict soil loss from discrete homogeneous land surfaces over long periods of time. GAMES (Guelph model for evaluating effects of agricultural management systems on erosion and sedimentation; Cook et al., 1985) and GAMESP which includes phosphorus loss predictions use the Universal Soil Loss Equation (USLE) to predict removal and soil loss as well as delivery from fields on a seasonal and annual basis. Hydrological simulation is not included nor are sub-surface transport processes. ANSWERS (aereal non-point source watershed environmental response simulation, Beasley et al., 1982) is a distributed single event model which simulates surface and sub-surface runoff and soil loss from discrete land areas. This model has seen widespread application in the United States. These models are much simpler and easier to use but lack the detailed process description to effectively simulate the total effects of improved land management practices in the long term.

The U.S. EPA has invested considerable time and resources in the development and testing of the predecessor models of HSPF. Since 1971 the U.S. EPA Environmental Research Laboratory has conducted a comprehensive research program to establish datasets and develop agricultural runoff models and evaluate proposed land management practices. The following field studies were undertaken for this purpose:

- four small Piedment watersheds in Georgia near Watkinsville were monitored from 1972 to 1975 for soil, herbicide and plant nutrient loss (Smith et al., 1978);
- two test catchments near East Lansing, Michigan, were monitored for herbicide and nutrient losses (Ellis et al., 1978);
- Four Mile Creek, Iowa was monitored from 1976 to 1980 for runoff, soil, plant nutrient, and herbicide losses (Baker et al., 1979);
- a tidewater area of North Carolina was monitored for herbicides, nutrients and runoff in a pre and post development study (Gilliam and Skaggs, 1980); and
- Sandusky Basin, Ohio, was the subject of a 3-5 year river basin scale nutrient and sediment transport study (Baker, 1979).

The results of model testing using the datasets gathered in these studies has guided researchers in estimating process rates and watershed behaviour parameters under a variety of conditions (Imhof et al., 1983; Donigian et al., 1983; Smith et al., 1978).

The PLUARG studies investigated non-point source pollution in the Great Lakes Basin in the mid 1970's recognizing that non-point sources of soil, nutrient and pesticides were a significant portion of total loadings to the Great Lakes and in fact were significantly higher than point source loadings in some areas (PLUARG 1978a). As part of this program, 11 agricultural watersheds in Ontario were selected for intensive studies from 1974 to 1977. One of these watersheds was the Nissouri Creek Watershed (termed AG-5) and is the subject of this study. The Nissouri Creek (also called Holiday Creek) Watershed was selected because it is representative of a much larger area in Southern Ontario, in terms of soil pollutant transfer potential. The silt loam soils and land management practices of this watershed were felt to be representative of an area of about 3,050 km^2 in the Lake Erie Basin.

PLUARG observations for the Nissouri Creek Watershed are reviewed in the next chapter. PLUARG did not attempt to develop land management models but rather was the first comprehensive effort to rank and quantify non-point sources of various water quality parameters by land characteristics and land use. Extensive databases were developed and have been the basis for setting research and conservation priorities since then. The PLUARG studies confirmed a number of theories regarding the origin and fate of non-point source pollution as well as giving direction to future research by identifying areas of weakness in our base of knowledge.

2.2 Objectives and Scope

The Ontario Ministry of the Environment has recognized the need for the predictive technology incorporated in HSPF. This model has immediate application to agricultural land management planning in the Great Lakes Basin. Other related applications include:

- urban development planning to examine the effectiveness of measures designed to reduce the impacts of urban development and land use changes on land and receiving waters;

- instream and lake/reservoir frequency analysis and lethality analysis to protect fisheries;

- watershed planning to predict the effect of development related point and non-point source pollutant loadings on future water quality;

- reservoir studies to optimize reservoir operation for flow augmentation and flood control;

- time series data (hydrologic, water quality and meteolologic) manipulation, summary, and frequency analysis;

- analysis of the long term effects of interbasin water transfers;

- analysis of groundwater pumping and irrigation schemes on watershed hydrology and water quality; and

- studies of chemical mobility in the environment, as required in the application for approval of pesticides for various uses and for selecting waste disposal sites for hazardous contaminants.

In 1983, MOE initiated a three year data collection and model testing program centering on a Southwestern Ontario agricultural watershed much like those conducted on Four Mile Creek and the Georgia watersheds (Imhof et al., 1983 and Smith et al., 1978). The objectives of this program include the following:

- collect data on hydrology, water quality, watershed characteristics and soil types in a watershed study for a 30 month period;
- collect data on the properties of atrazine and the management practices associated with its use in the study area;
- investigate the contributing factors which lead to atrazine, phosphorus and soil transport by surface runoff and subsurface outflow from the study watershed;
- investigate the effect of land management practices on soil erosion and sediment transport, phoshorous transport and atrazine transport from the watershed.
- calibrate a comprehensive land management model (HSPF) and simulate watershed hydrology, soil loss, phosphorus and atrazine transport from the watershed;
- evaluate the effectiveness, accuracy, utility and practicality of using watershed modelling to predict the environmental fate of agri-chemicals and the effectiveness of conservation management practices; and
- recommend appropriate land management practices for controlling the loss of soil and agri-chemicals from agricultural areas in Ontario.

In meeting this objective BEAK was contracted to undertake a comprehensive field study and modelling exercise. The Nissouri Creek Watershed was fully instrumented and monitored from May 1984 to December 1986 for surface water quantity and quality, meteorology, and sub-surface runoff quantity and quality. Historical databases were assembled and summarized and site measurements were made to characterize the watersheds soils, land use and drainage. MOE, Water Resources Branch conducted field level studies of atrazine decay to aid in process definition. Surveys of land owner use of atrazine were also conducted to characterize the land management practices (Hazardous Contaminants Coordination Branch). Literature was reviewed to aid at all stages of the program from initial study design to model parameter selection in order to take advantage of existing databases and past experience.

A modelling exercise was undertaken in order to investigate conservation land management practices and demonstrate the applicability of watershed modelling to land management.

HSPF time series and descriptive input data was prepared, the watershed was discretized in a lumped parameter mode, the model was calibrated on one full year of watershed data, and validated using a second complete year of data. In addition, the model was used in a demonstration mode to predict the benefit of various broadly applied conservation management schemes and the models utility modules were applied in separate demonstrations of their usefulness. Conclusions regarding runoff processes were made based upon model predictions. Finally, recommendations were formulated regarding the use of models in land management, the procedures for conducting further data collection programs in watersheds, model testing procedures, the most likely candidate land management practices for further consideration, and future research needs.

This is the final project report. The following chapters provide a description of the study area; the historical database; the field study program, methods, and results; the modelling process including initial set up, calibration and validation; a simulation demonstration of the benefit of some land management practices; and comments and recommendations.

3.0 STUDY AREA

3.1 General

The Nissouri Creek Watershed lies within Oxford County (Zorra Township) in the Southwestern Ontario Peninsula. The creek discharges runoff from a gently rolling portion of the Oxford Till Plain to the Middle Thames River just upstream of the Town of Thamesford. The centre of the watershed is approximately equidistant from the cities of Woodstock and London which are 20 to 25 kilometers to the southeast and southwest respectively. The location of the watershed is illustrated on a regional map of Southwestern Ontario in Figure 3.1. A larger scale map, (see Figure 3.2) shows the shape of the watershed and its surface drainage system.

The watershed is approximately 31 km^2 in area with a maximum width and length of 5 and 9 km respectively.

The watersheds geophysical, socio-economic and agronomic characteristics are described in the following section.

3.2 Topography

The maximum surface elevation change over the watershed is from 382 m (above mean sea level) in the northwest to 290 m (above mean sea level) at the mouth, over a distance of 8 km. Slopes range from nearly flat in the central section to more than 15% in localized areas in the northern and southern regions of the watershed and along the streambanks. Generally, slopes are in the 1 to 5% range.

In general, the area can be described as gently rolling with hilly areas and depressions on the west side and moderating to gently undulating on the east side.

3.3 Geology

The Nissouri Creek Watershed is underlain by the Detroit River Formation. This material consists of dolomite and limestone with some gypsum and chert. There are no bedrock outcrops in the watershed although bedrock has been exposed along the deep

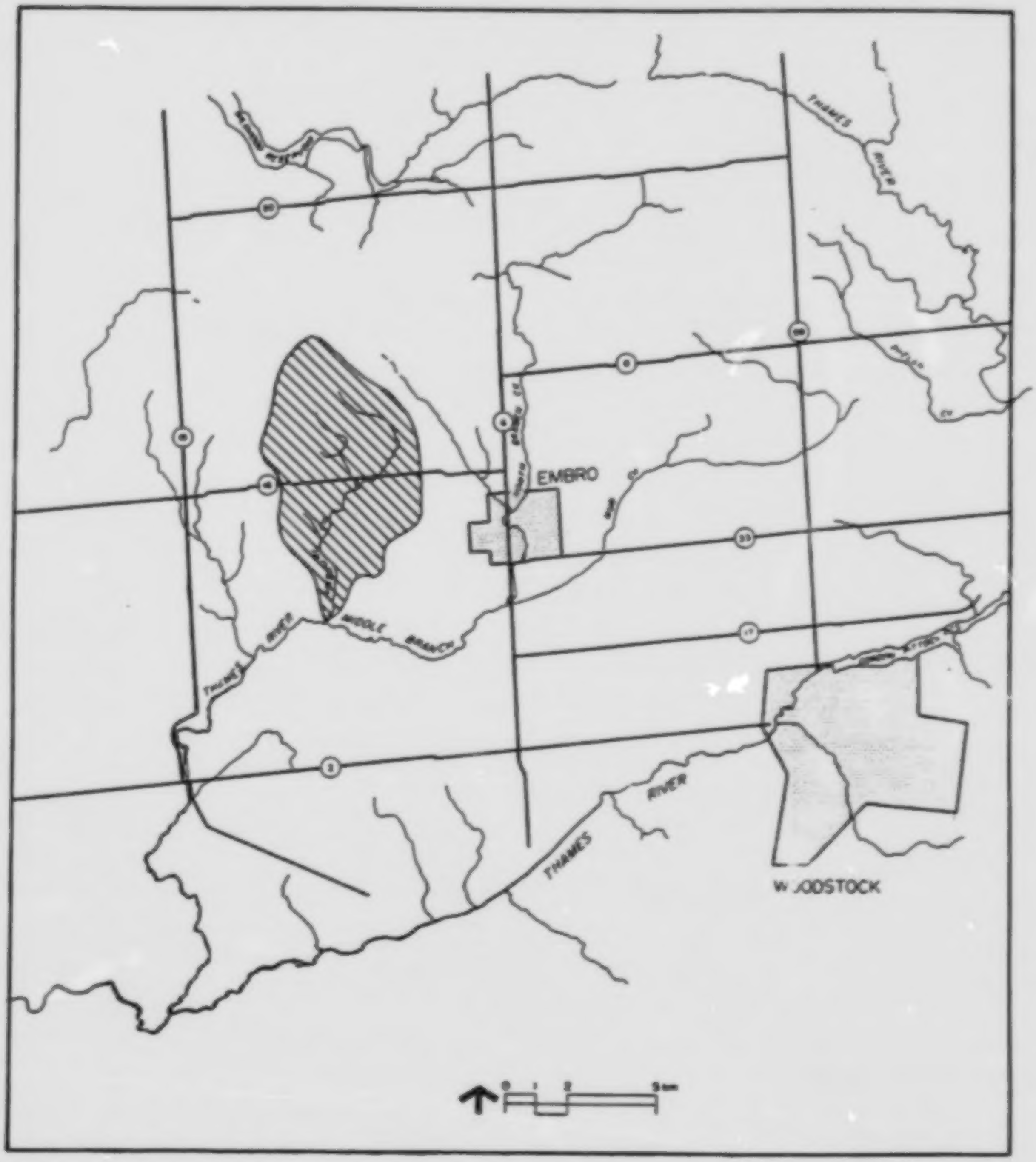

THAMES RIVER
NORTH BRANCH CR
EMBRO
THAMES RIVER
MIDDLE BRANCH
THAMES RIVER
2
THAMES RIVER
WOODSTOCK
0 1 2 3 km

FIGURE 3.1

Location of the Nissouri Watershed
in Southwestern Ontario

▨ NISSOURI WATERSHED

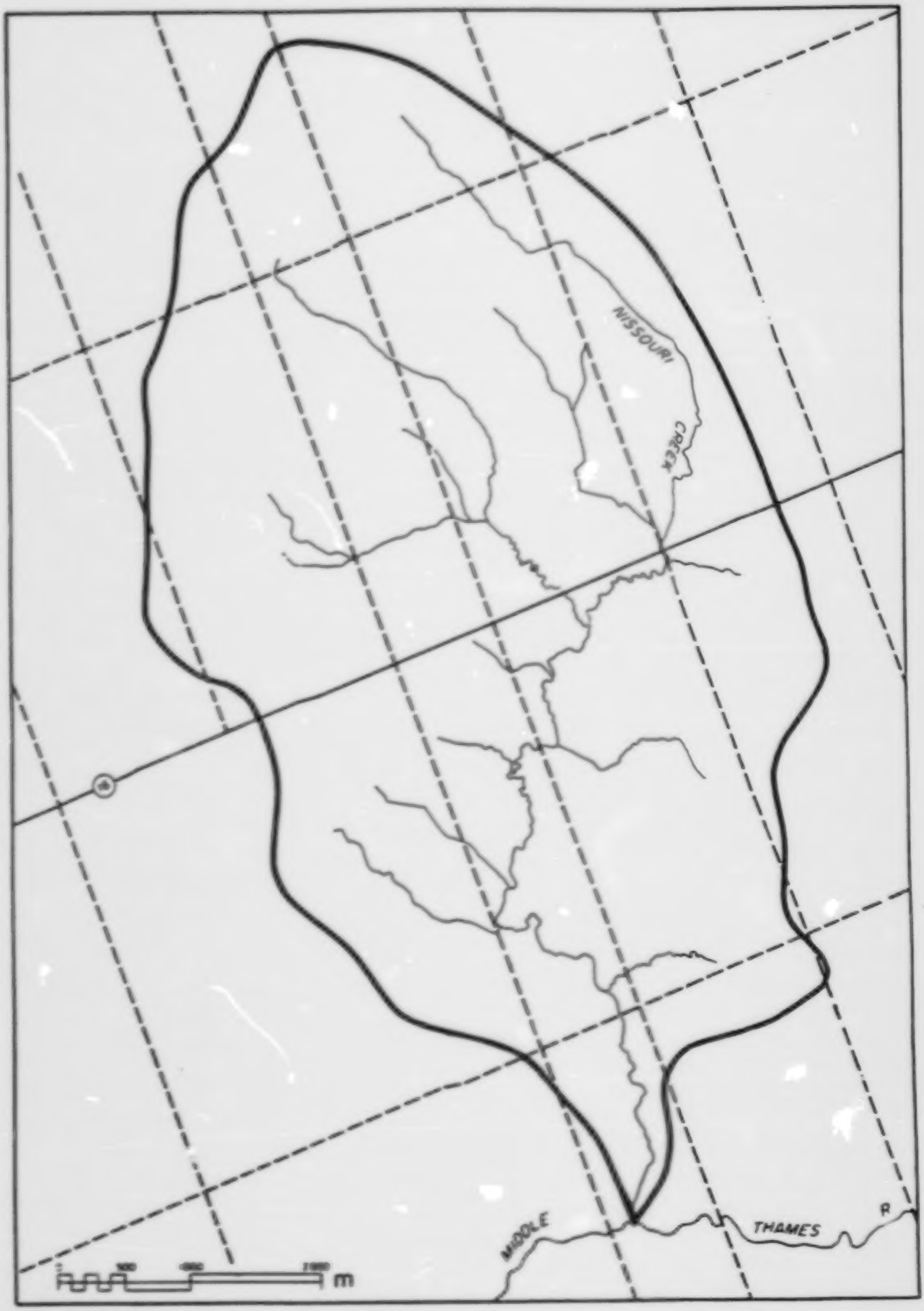

NISSOURI CREEK
MIDDLE THAMES R
0 500 1000 2000 m
LEGEND
TOWNSHIP ROADS
COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY

FIGURE 3.2

Nissouri Watershed
Drainage Area

Thames River valleys nearby. Beachville, 10 km to the southeast, is the site of active limestone quarrying.

3.4 Soils and Glacial Geology

The watershed lies on the 150,000 ha Oxford Till Plain. The surface of the plain is drumlinized although no drumlins are apparent in this watershed. The till is pale brown, calcareous boulder loam dominated by Norfolk limestone and grey or pale brown dolomite.

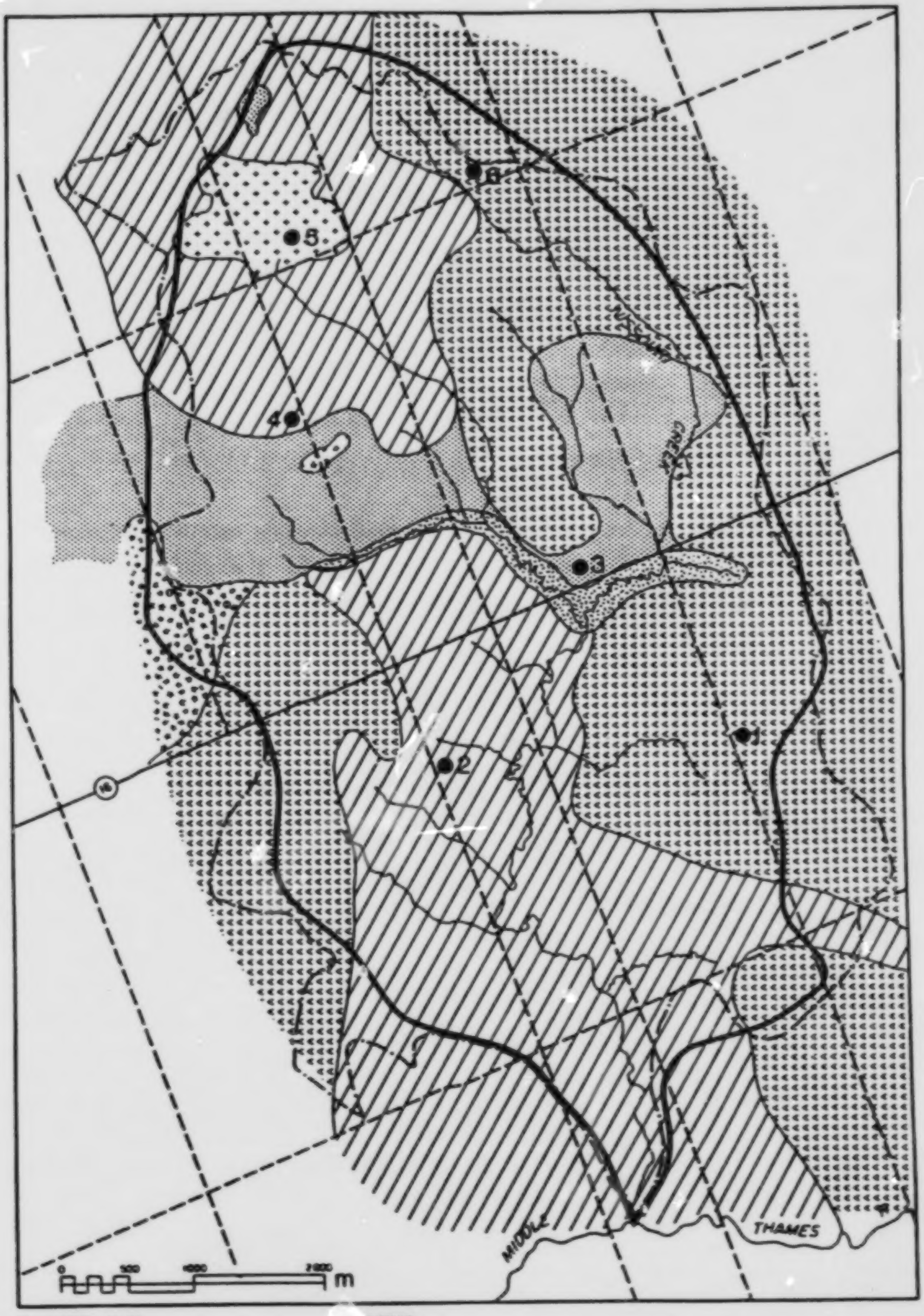
The Thames River and its headwaters flow within well-marked oversized valleys cut by glacial meltwaters across the plain.

The dominant soil types in the area are Guelph Loam and Honeywood-Guelph Complex (silt loam) (grey-brown podzolic) and the Embro silt loam. The Guelph loam is among the best agricultural soils in Ontario owing to its good drainage, loamy texture, moderate water holding capacity, neutral reaction and lack of extreme stoniness. Upland locations have dark grey soils with moderately high organic content and depths of more than 0.5m. Erosion has reduced this layer on steep slopes and has deposited material in the depressions and at the bottom of slopes.

The Embro silt loam and the Honeywood-Guelph Complex have finer particle sizes and display imperfect drainage. These soils are usually associated with smooth topography on broad plains which may have been lacustine basins. These soils are up to 1.0 metre thick overlying stoney loam till. Surface soils are black with high organic content. A sub-surface silty clay loam layer inhibits drainage. An extensive tile drainage network has been developed to alleviate this problem in the Nissouri Creek Watershed.

Bottom land is found along streambeds within the watershed in relatively localized areas. This alluvial material has variable agricultural adaptability depending on the depth of the water table. Muck (high organic material derived from litterfall etc.) is also present in swampy areas, especially on the west side of the watershed.

Figure 3.3 shows the surface soil designations as originally reported in the Ontario Soil Survey by the Canadian Department of Agriculture (1961) using the old field mapping



NISSOURI
CREEK
MIDDLE
THAMES
16
1
2
3
4
5
6
0
500
1000
2000
m
LEGEND
TOWNSHIP ROADS
16 COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
3 ● SOIL SAMPLING SITES
GUELPH LOAM
EMBRO SILT LOAM
HONEYWOOD-GUELPH COMPLEX
TAVISTOCK SILT LOAM
MUCK
BOTTOM LAND
PARKHILL LOAM

FIGURE 3.3

Nissouri Watershed Surface Soil Types and Sampling Sites system. The three dominent soil types described here; Guelph Loam, Embro silt loam, and Honey wood Guelph Complex occupy 45%, 36% and 12% of the area respectively with small areas of Tavistock silt loam, Parkhill loam, muck and bottom land on the remaining 7% of the watershed.

The PLUARG study conducted detailed soil investigations in this watershed and produced a detailed soil map (PLUARG, 1979). Figure 3.4 displays the soil series map produced using the newer taxonomic soil classification system. This system uses soil series numbers and their relative abundance along with identifiers for slope phase and stoniness phase.

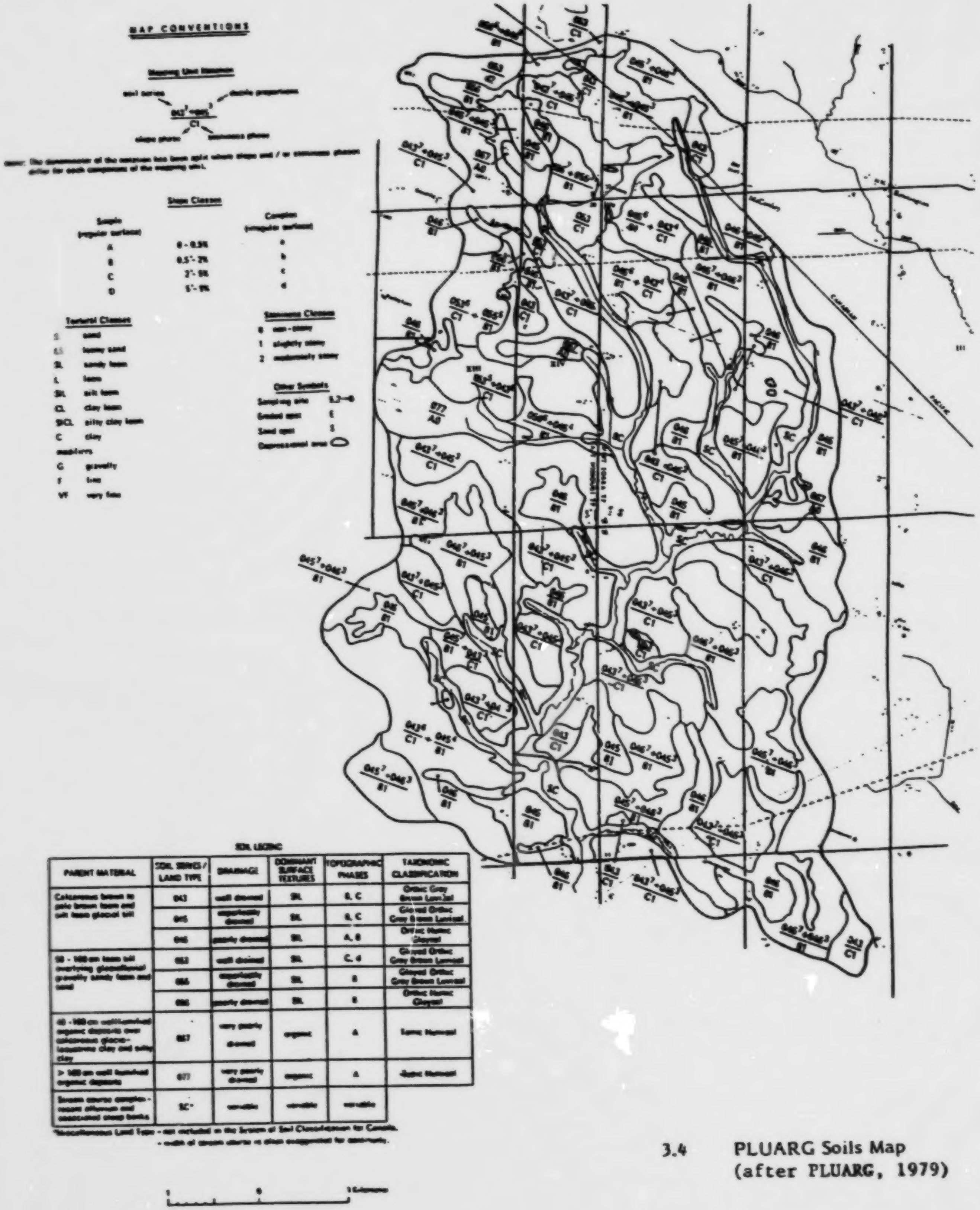
Table 3.1 summaries features of this soil map including relative abundance of the soil series and the closest corresponding soil series used in the old classification system. A further discussion of Nissouri Creek Watershed soils in terms of physical and chemical characteristics, is presented in the next chapter.

3.5 Land Use

The majority of the Nissouri Creek Watershed has been under intensive cultivation for row crops with some areas used for grain production, pasture, hay and orchards. About 13% of the land is not used directly for agriculture. Non-agricultural uses include roads, residential lots and forested areas.

The dominant agricultural activity in the area is dairy farming with large areas dedicated to sileage corn production. Significant areas have been seeded with small grains (i.e., oats, winter wheat); and soybeans, orchards, vegetables, hay and pasture are also found. Hog production is also present in the area.

There are about 55 farms in the watershed with average cultivated areas of about 50 hectares per farm. In 1985 about 1,530 hectares was dedicated to corn production with 1,170 hectares in other agricultural uses. In 1986 about 1,110 hectares was dedicated to corn with 1,590 hectares in other agricultural uses. There are no areas set aside for commercial, institutional, recreational, or industrial uses.


MAP CONVENTIONS
Mapping Unit Notation
soil series
decile proportions
$\frac{043^7 + 045^3}{C1}$
slope phase
stoniness phase
Note: The denominator of the notation has been split where slope and / or stoniness phases differ for each component of the mapping unit.
Slope Classes
Simple (regular surface)
Complex (irregular surface)
A 0 - 0.5% a
B 0.5+ - 2% b
C 2+ - 5% c
D 5+ - 9% d
Textural Classes
S sand
LS loamy sand
SL sandy loam
L loam
SiL silt loam
CL clay loam
SiCL silty clay loam
C clay
modifiers
G gravelly
F fine
VF very fine
Stoniness Classes
0 non-stony
1 slightly stony
2 moderately stony
Other Symbols
Sampling site S2—0
Eroded spot E
Sand spot S
Depressional area ⬭
SOIL LEGEND
1 0 1 Kilometre

PARENT MATERIAL	SOIL SERIES / LAND TYPE	DRAINAGE	DOMINANT SURFACE TEXTURES	TOPOGRAPHIC PHASES	TAXONOMIC CLASSIFICATION
Calcareous brown to pale brown loam and silt loam glacial till	043	well drained	SiL	B, C	Orthic Gray Brown Luvisol
	045	imperfectly drained	SiL	B, C	Gleyed Orthic Gray Brown Luvisol
	046	poorly drained	SiL	A, B	Orthic Humic Gleysol
50 - 100 cm loam till overlying glaciofluvial gravelly sandy loam and sand	053	well drained	SiL	C, d	Gleyed Orthic Gray Brown Luvisol
	055	imperfectly drained	SiL	B	Gleyed Orthic Gray Brown Luvisol
	056	poorly drained	SiL	B	Orthic Humic Gleysol
40 - 160 cm well-humified organic deposits over calcareous glacio-lacustrine clay and silty clay	087	very poorly drained	organic	A	Terric Humisol
> 160 cm well humified organic deposits	077	very poorly drained	organic	A	Typic Humisol
Stream course complex - recent alluvium and associated steep banks	SC*	variable	variable	variable	

*Miscellaneous Land Type - not included in the System of Soil Classification for Canada.
- width of stream course is often exaggerated for clarity.

3.4 PLUARG Soils Map (after PLUARG, 1979)

TABLE 3.1

SOIL SERIES OF THE NISSOURI WATERSHED

Soil Series	Particle Size Class	Slope/Stoniness* Phases	Areal Extent %	Agricultural Capability	Old Classification Series
043	course loamy	C1	24	1	Guelph Loam
045	fine loamy	B1, C1	26, 7	1	London Loam
046	fine loamy	B1	23	2w	Parkhill Loam
053	fine loamy	C1, d2	5, 1	1, 3T	no correlation
055	fine loamy	B1	2	1	no correlation
056	fine loamy	B1	2	3W	no correlation
067	humic clayey	A0	1	unclassified	muck
077	humic clayey	A0	2	unclassified	muck
SC	stream course complex	-	8	variable	no correlation

*Slopes:
A 0-0.5% regular
B 0.5-2% regular
C 2-5% regular
d 5-9% irregular

Stoniness:
0 non stoney
1 slightly stoney
2 moderate stoniness

Table 3.2 is a summary of information compiled by PLUARG for the Nissouri Creek Watershed in the mid 1970's. Most of this information is still relevant today.

3.6 Meteorology

The long term meteorological records from London and Woodstock have been summarized and are representative of the Nissouri Creek Watershed area due to their proximity and similar topography. Tables 3.3 and 3.4 list monthly normals for London and Woodstock respectively for average air temperature, bright sunshine, precipitation and relative humidity (Woodstock only). Figure 3.5 is the normal (25 year) wind rose for London.

The only significant long term or seasonal difference between the weather patterns at London and Woodstock is in terms of snowfall. London normally receives an additional 80 mm (water equivalent) of snow per year to that received at Woodstock.

Minor climatological differences do exist between London, Woodstock and the Nissouri Creek Watershed due to topography, proximity to open water and urbanization but these are believed to have an insignificant effect in the long term. Precipitation can vary significantly within a few kilometres during individual thunderstorm events. However, over the entire thunderstorm season these spatial differences tend to disappear.

3.7 Hydrology

Imperfect drainage due to silty clay soil layers in the broad lacustrine plains of the Nissouri Creek Watershed have necessitated extensive tile drainage. Sub-surface drain patterns range from simple irregular municipal drains which generally follow the natural depressions of the land to systematic networks which underlay entire fields. Most of the watershed is tile drained to some extent. Only the main stream channel remains in a natural state.

Man made drainage structures have greatly affected the hydrologic regime of the watershed by reducing surface runoff and peak streamflow and at the same time they have extended the duration of the hydrograph and increased the overall hydraulic yield by providing more complete drainage after precipitation events. Baseflow may be reduced somewhat by the sub-surface drains as less water passes downwards to the groundwater table.

TABLE 3.2: NISSOURI CREEK WATERSHED CHARACTERISTICS FROM PLUARG (1975-1976)

Total Area of Watershed in Hectares	3,000
% Cultivated Land in Watershed	58.1
% of Soil which is Clay	20.1
% of Soil which is Sand	25.0
Erosion Potential - Dimensionless	1.7
Surface Pollutant Potential - Dimensionless	0.40
Ground Water Pollutant Potential - Dimensionless	0.40
Perennial Stream Density in km/km^2 (SD)	0.732
Rural Residences per km^2	1.4
Road Density in km/km^2	2.1
% Row Crops	45.9
% Corn	42.3
% Soybeans and Whitebeans	0.001
% Tobacco	0.001
% Vegetables	3.6
% Cereals	12.2
% Pasture and Hay	22.8
% Orchards	0.001
% Woods and Unimproved Land	15.4
% Non Agricultural	3.7
Animal units per Hectare	0.61
Soil P_2O_5 - Dimensionless	23.3
Fertilizer Nitrogen Input kg/ha	45.6
Manure Nitrogen Input kg/ha	43.7
Fertilizer Phosphorus Input kg/ha	16.8
Manure Phosphorus Input kg/ha	10.0
Total Nitrogen Input from Manure and Fertilizer kg/ha	89.3
Total Phosphorus Input from Manure and Fertilizer kg/ha	26.8
Slope - m/km	8.57
% Tile Drained	98.0
% Exposed Streambank (EX)	6.0
Fertilizer Potassium kg/ha	29.9
Manure Potassium kg/ha	39.8
Total Potassium kg/ha	69.7
Exposed Streambank km/km^2: $ES = \frac{SD \times EX}{100}$	0.04

TABLE 3.3 MONTHLY METEOROLOGICAL NORMALS AT LONDON, ONTARIO, 1951-80

Month	Temp (°C)	Bright Sunshine (hrs.)	R.H. (%)	Precipitation Rainfall (mm)	Snowfall (cm)	Total* (mm)
January	-6.6	71	84	27.9	55	75.2
February	-6.1	97	82	26.7	38.9	60.5
March	-0.9	121	81	49.7	27.9	75.1
April	6.4	167	73	72.6	9.1	81.2
May	12.4	230	68	66.5	0.3	66.8
June	17.9	244	69	73.6	-	73.6
July	20.3	274	69	72.4	-	72.4
August	19.5	246	74	80.3	-	80.3
September	15.4	173	78	78.6	-	78.6
October	9.4	142	78	71.6	1.9	73.4
November	3.1	75	84	62.4	24.4	84.7
December	-3.5	56	85	43.5	51.3	87.5
TOTAL				726	209	909.4

*Total precipitation is equivalent to total rainfall plus the water equivalent of the snow and all other forms of frozen precipitation.

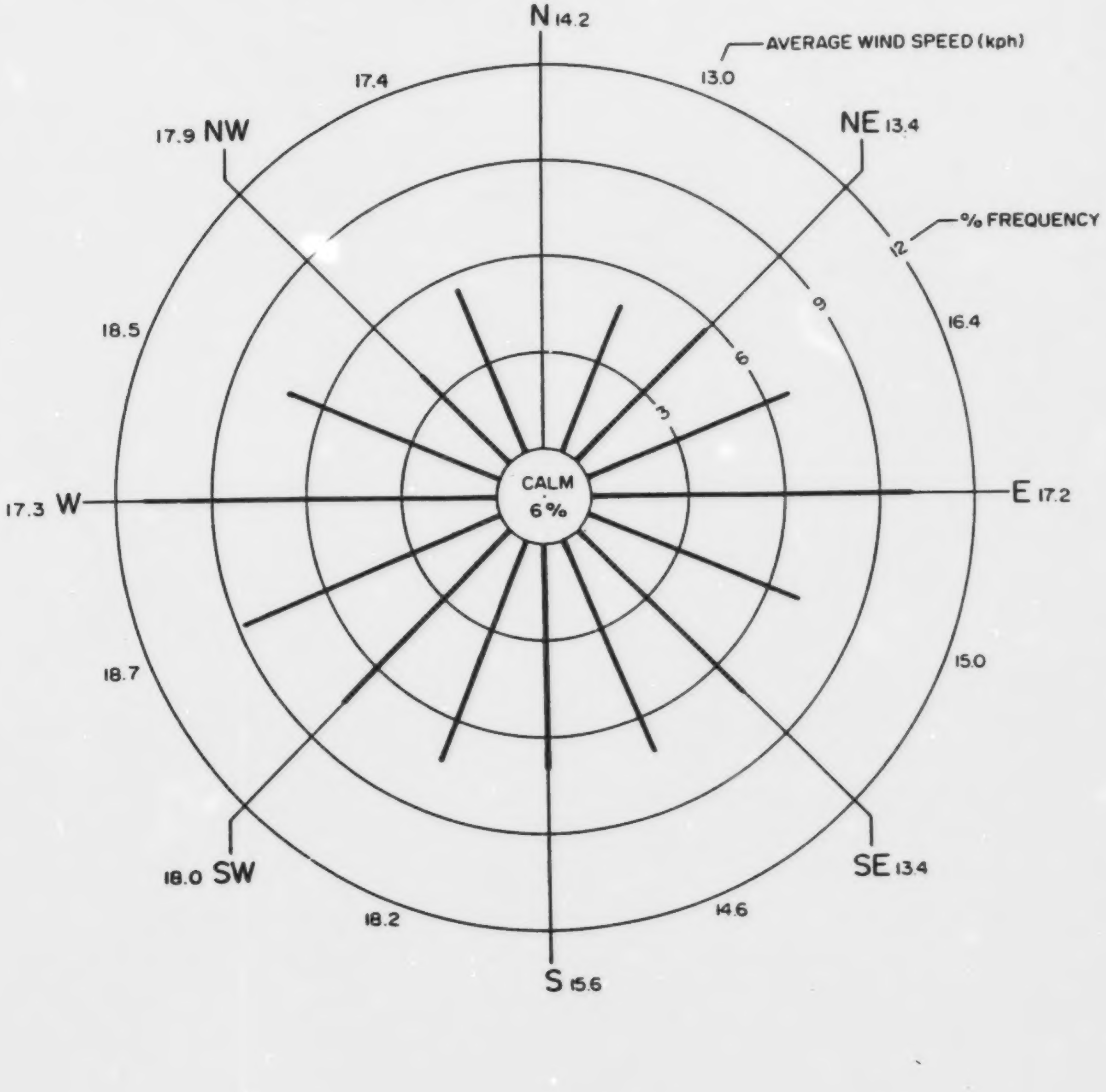
TABLE 3.4 MONTHLY METEOROLOGICAL NORMALS AT WOODSTOCK, ONTARIO, 1951-80

Month	Temp (°C)	Bright Sunshine (hrs.)	Precipitation Rainfall (mm)	Precipitation Snowfall (cm)	Precipitation Total* (mm)
January	-6.6	83	25.5	33.8	60.2
February	-5.8	94	28.3	23.1	49.9
March	-0.9	130	50.5	19.5	70.1
April	6.3	171	70.3	5.9	76.2
May	12.4	238	64.5	0.3	64.8
June	17.8	260	82.0	-	82.0
July	20.1	298	75.4	-	75.4
August	19.3	264	88.4	-	88.4
September	15.4	209	74.2	-	74.2
October	9.4	168	72.3	1.4	73.7
November	3.0	88	59.0	12.7	71.7
December	-3.4	67	45.6	29.3	74.9
Total			736	126	861.6

*Total precipitation is equivalent to total rainfall plus the water equivalent of the snow and all other forms of frozen precipitation.

FIGURE 3.5

Wind Rose for London Airport (Yearly Average) for the Period 1955-1980



The streamflow at the most downstream road crossing in the Nissouri Creek Watershed was monitored as part of the PLUARG study from April 1975 to November 1977. Runoff during this period was generally higher than normal as evidenced by the records of streamflow rate on the Middle Thames River at Thamesford. The 1975-77 streamflow rates at this site generally exceeded the long term average rates on a monthly basis. The precipitation records for this same period indicate that there was above average precipitation. The same long term records show that there has been a steady increase in total annual precipitation and total streamflow from 1965 to 1986 so that 1986 streamflow rates were almost double the rates measured in the mid 1960's. It is unclear whether this is part of a long term climatological trend or merely random variability.

Figure 3.6 illustrates the monthly means and daily extremes of streamflow in the Nissouri Creek for the 30 month PLUARG monitoring period. The stream flowed continuously during this period and daily average flows frequently exceeded $3m^3/s$ following precipitation events. Low baseflow occurred in the June to August period and peak flows occurred in February to May. Storm hydrographs usually have a duration of less than 3 days as hydraulic delivery within the system is rapid.

3.8 Water Chemistry

Because of the PLUARG activities in the Nissouri Creek Watershed a great deal of water quality information was collected from May 1975 to April 1977. Parameters studied included the nutrients; phosphorus and nitrogen; suspended sediments; heavy metals including lead, copper and zinc; and toxic materials (insecticides, herbicides and PCB). Several other parameters were monitored on a less intensive basis. The full database is summarized in the PLUARG series reports (PLUARG 1978a, 1978b, 1978c, 1978d). The PLUARG results of phosphorus, suspended sediment or soil and atrazine (and desethyatrazine, a metabolite of atrazine) monitoring are summarized here. Table 3.5 summarizes the sediment-soil loss information for the 1976 calendar year. Note that streambank erosion is relatively insignificant as a sediment source. The Nissouri Creek Watershed soil loss for 1976 was near the average for Lower Great Lakes drainage basin as presented in Figure 2.1.

Table 3.6 lists summary information for phosphorus loadings from various sources in the watershed. Note that cropland is the source of over 80% of the phosphorus load and

FIGURE 3.6 Mean Monthly and Daily Extreme Flows in the Nissouri Creek, April 1975-November 1977

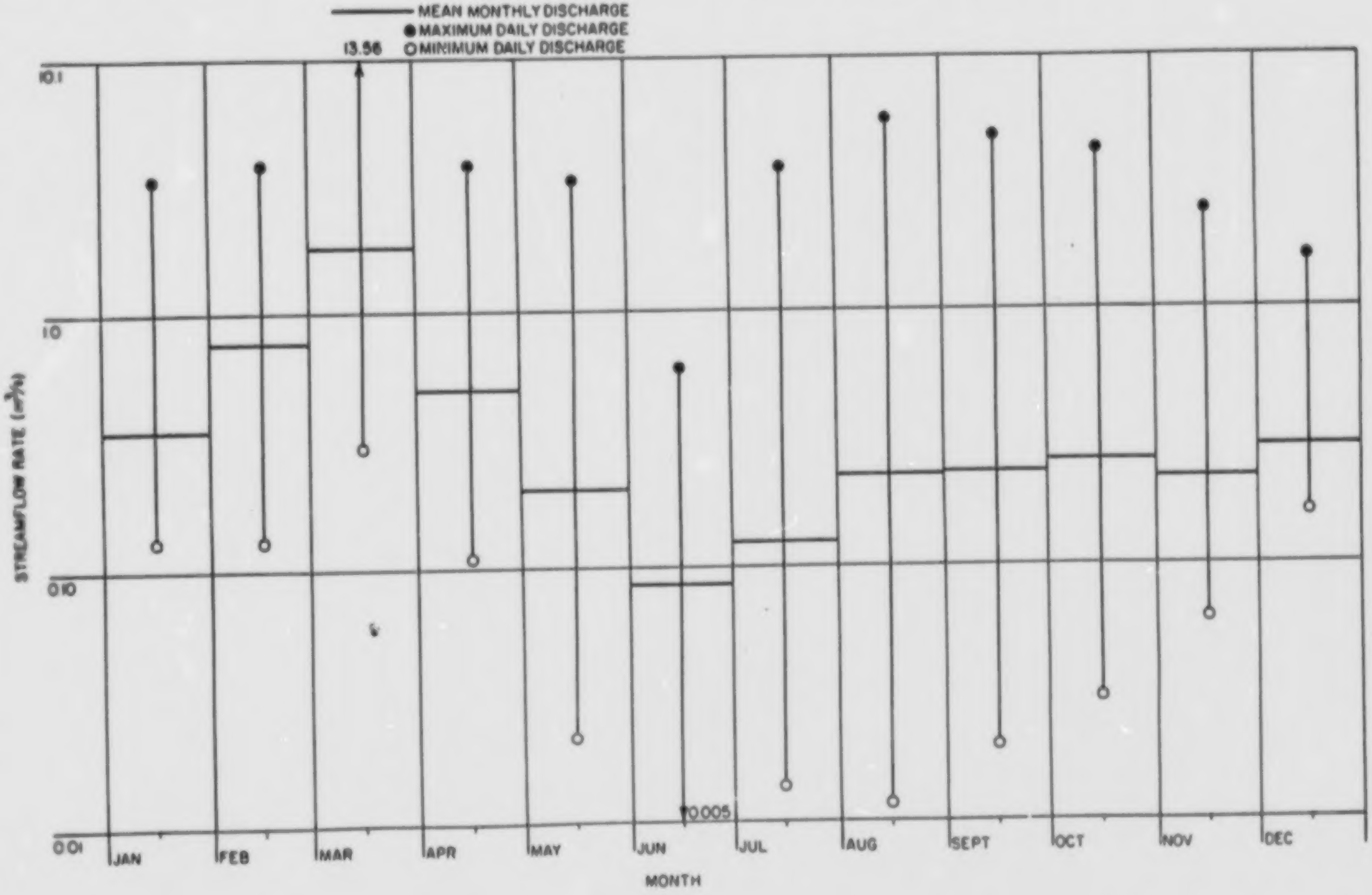


TABLE 3.5 PLUARG SEDIMENT - SOIL LOSS SUMMARY, 1976 (PLUARG, 1978e)

Total Sediment Load (kg/ha/yr) =	351
Streambank Erosion (kg/ha/yr) =	5
Cropland Erosion (kg/ha/yr) =	346
Total Watershed Sediment Load (tonnes) =	1,085

Delivery Ratio (DR) % = $\frac{\text{Stream Sediment Load}}{\text{Total Erosion}}$ x 100 = 7, 16, 21 (three methods)

Avg. DR (%) = 15

TABLE 3.6 ESTIMATED AND MEASURED ANNUAL TOTAL AND DISSOLVED PHOSPHORUS LOAD (TONNES) FROM SOURCES WITHIN THE WATERSHED (PLUARG, 1978e)

Total Phosphorus measured (Beale Estimator)	4.60
Total Phosphorus measured (NAQUADAT)	3.21
Streambank Erosion	0.01
Cropland	1.96
Livestock	0.39
Unimproved Land	0.04
Total Estimated	2.40
Total Measured Dissolved Phosphorus	1.28
Total Sediment Phosphorus = Total Phosphorus	0.72

dissolved phosphorus accounts for 28% of the total load (PLUARG, 1978e). The 1976 phosphorus losses for this watershed were in the highest range within the Lower Great Lakes drainage basin as presented in Figure 2.2.

Tables 3.7 to 3.10 list relevant information for atrazine and its metabolite, desethylatrazine. Losses of atrazine and desethylatrazine were about 0.4% of the amount applied with the majority of export (62%) occurring in the January to April period. Surface runoff accounted for about 61% of all atrazine losses from 1975 to 1977 with spills accounting for an estimated 8% of losses (PLUARG, 1978b).

Tables 3.11 and 3.12 summarize the unit area loadings and total loadings for suspended solids, total phosphorus, ortho-phosphorus, total dissolved phosphorus and some pesticides and toxicants for the study period by season. Table 3.13 summarizes the frequency of occurrence of various concentrations of atrazine and desethylatrazine in stream water during the study (PLUARG, 1978d).

Streamflow rates in the Middle Thames River at Thamesford were slightly higher than the long term normals (1950-86) for the PLUARG study. However, more recent records suggest that a trend to higher precipitation and streamflow may be in effect. Average streamflows since the completion of the PLUARG monitoring period have been consistently higher. The water quality implications of this are mixed. Higher precipitation will generally cause more surface runoff and concomitant erosion of soils and runoff of soil attached nutrients and pesticides, and dissolved material. This will result in higher stream loadings of agricultural chemicals and suspended solids following precipitation/snowmelt events. Conversely, higher precipitation will cause higher groundwater storage and baseflow rates and therefore lower pollutant concentrations due to higher dilution at low flow times. It follows then that periods of higher precipitation and stream flow are also periods with more extreme concentrations of pollutants. Total annual pollutant loadings will likely display a general increase in wet years.

TABLE 3.7 RATES OF APPLICATION AND LOSS OF ATRAZINE AND ITS METABOLITE (PLUARG, 1978b)

Atrazine Application Rate (kg/ha/yr):		0.66 whole watershed
(1975-77)		2.01 treated corn areas
Losses of Atrazine (g/ha/yr)	1975-76	2.27 whole watershed
and desethylatrazine:	1975-76	7.0 treated corn areas
	1976-77	3.10 whole watershed
	1976-77	9.50 treated corn areas

TABLE 3.8 UNIT AREA LOADINGS OF ATRAZINE AND ITS METABOLITE BY SEASON (PLUARG, 1978b)

			% of Total
Total Atrazine & Desethylatrazine Load (mg/ha): 1975-77	May-Aug.	1623	30
	Sept.-Dec.	430	8
	Jan.-Apr.	3317	62
	Total	5370	100

TABLE 3.9 AMOUNT OF ATRAZINE AND DESETHYLATRAZINE LEAVING THE WATERSHED BY MONTH, 1975-77 (KG) (PLUARG, 1978b)

1975	May	0.25		Nov.	0.07	May	0.54		Nov.	0.20
	June	0.87		Dec.	0.59	June	0.10		Dec.	0.07
	July	0.11	1976	Jan.	0.39	July	2.19	1977	Jan.	0.04
	Aug.	0.09		Feb.	1.87	Aug.	0.72		Feb.	0.27
	Sept.	0.12		March	2.20	Sept.	0.03		Mar.	4.42
	Oct.	0.05		Apr.	0.21	Oct.	0.16		Apr.	0.55
									Total	16.11

TABLE 3.10 LOSSES OF ATRAZINE AND DESETHYLATRAZINE IN SURFACE, SUBSURFACE AND SPILLS BY SEASON, 1975-77 (PLUARG, 1978b)

	May-Aug.	Sept.-Dec.	Jan.-Apr.	Total
Storm Runoff (kg)	1.69	0.45	7.61	9.75
Base Flow (kg)	1.87	0.84	2.34	5.05
Spills (kg)	1.31	0.00	0.00	1.31
Total (kg)	4.87	1.29	9.95	16.11

TABLE 3.11: NISSOURI WATERSHED UNIT AREA LOADINGS FOR SUSPENDED SOLIDS, NUTRIENTS AND HEAVY METALS (PLUARG, 1978d)

Total**	Season*			Unit Area	Total**	Season			Unit Area
Load	I	II	III	Load	Load	I	II	III	Load
T/yr	%	%	%	kg/ha/yr	T/yr	%	%	%	kg/ha/r
	SUSPENDED SOLIDS					TOTAL PHOSPHORUS			
1990.0				661.7	4.60				1.53
1053.6	25.7	71.7	2.6	351.2	3.21	34.6	62.3	3.2	1.07
822.9	48.3	48.3	3.4	274.3	2.42	52.9	43.3	3.8	0.81
	ORTHO PHOSPHORUS					TOTAL DISSOLVED PHOSPHORUS			
0.96				0.32	1.28				0.43
0.72	54.0	39.0	6.9	0.24	1.02	44.7	48.8	6.5	0.34
0.69	72.9	20.9	6.4	0.23	0.91	63.3	30.3	6.4	0.30

* I = Dormant, cold-warming (Jan.-April); II = active (May-August); III = dormant, cooling-cold (Sept.-Dec.)

** Upper line of values = Beale Method, 1976 only
Middle line of values = NAQUADAT Method, 1976 only
Lower line of values = NAQUADAT Method, 1975-1977 2-year mean

*** Includes estimates - some watersheds had most concentrations below detection limit

TABLE 3.12: NISSOURI WATERSHED UNIT AREA LOADINGS FOR PESTICIDES AND TOXICANTS (PLUARG, 1978d)

Total** Load T/yr	Season* I %	Season* II %	Season* III %	Unit Area Load kg/ha/yr	Total** Load T/yr	Season I %	Season II %	Season III %	Unit Area Load kg/ha/r
	2,4-D***					ATRAZINE AND DESETHYL ATRAZINE***			
0.030	0.0	80.0	20.0	0.010	8.68	53.8	40.9	5.3	2.89
0.087	13.8	80.2	6.0	0.018	5.21	62.8	31.7	5.5	1.74
	1976 DDT					DIELDRIN***			
0.046	82.6	15.2	2.2	0.015	0.000	0.0	0.0	0.0	0.000
0.053	65.0	20.9	14.1	0.029	0.000	0.0	0.0	0.0	0.000
	ENDOSULFAN***					POLYCHLORINATED BIPHENYLS			
0.013	98.5	0.0	1.5	0.004	0.641	82.5	11.1	6.4	0.214
0.012	100.0	0.0	0.0	0.004	0.505	76.4	13.7	9.9	0.168

* I = Dormant, cold-warming (Jan.-April); II = active (May-August); III = dormant, cooling-cold (Sept.-Dec.)

** Upper line of values = NAQUADAT Method, 1976 only
Lower line of values = NAQUADAT Method, 1975-1977 2-year mean

*** Estimates only - many concentrations below detection limit

TABLE 3.13 FREQUENCY OF OCCURRENCE AND CONCENTRATION OF ATRAZINE AND DESETHYL ATRAZINE IN STREAM WATER, MAY 1975 - APRIL 1977 (PLUARG, 1978b)

Period May - April	Analyses (#)	Concentration Ranges (ug/l) 0-0.04	0.04-0.09	0.1-1.0	1.1-10	10.1	Mean (SD)
1975-76	55	4	2	37	12	0	1.0 (3.1)
1976-77	56	3	2	38	13	0	0.89 (2.1)

4.0 FIELD STUDY PROGRAM

4.1 Scope

The field study and monitoring program was designed to meet two objectives. Firstly to allow for a detailed investigation of agri-chemical and soil transport and fate, and secondly to provide the data required for modelling the system. In fact, the data requirements of these two objectives overlap considerably.

The investigation of transport and fate processes requires that all major pathways and fluxes within the system be identified and assessed either directly through small scale or field level studies or indirectly through mass balance accounting wherever possible. Similarily, creating model input and watershed discretization information in a deterministic modelling scheme requires the same direct or indirect approach to process definition. The field study and laboratory components of this study were directed to this end in a practical and comprehensive manner bearing in mind the experiences of others working this area and the constraints of the program.

Field monitoring activities included routine and regular monitoring of key parameters including surface water hydrology and water quality as well as several meteorological parameters within the watershed. This information was used to build time series stores (TSS) used as input for the model and for model output evaluation. Model predictions provided the indirect assessment of material flux and mass balance.

Less frequent or occasional measurements were made during the course of the study to determine key physical watershed characteristics, surface water hydrology, chemical state variables, land use practices and other factors which could be observed directly. This information was used to aid in discretizing the watershed, establishing the models initial conditions and for checking predicted final conditions, estimating process variables, and assessing accurate automatic instrument calibration.

The overall field program was designed at the onset of the study following discussions with the involved agencies and further refined during the course of the project. Continuity was maintained throughout in terms of sampling and monitoring sites and key parameters.

Photograph #1: Station N4 Monitoring Installation

The following section provides a description of sampling and monitoring methods, sites and instrumentation as well as a summary of the resultant database.

4.2 Hydrology

4.2.1 Surface Water Hydrology

The surface water hydrology monitoring network consisted of four automatic streamflow monitoring installations. Site locations are indicated on Figure 4.1. The most upstream site, N4 measured surface runoff from an area of approximately 170 hectares, largely in corn production. This station provided an opportunity to examine the surface runoff from a small, clearly defined, headwater area in some detail. This scale is useful in model calibration as water quality and hydrology at this site showed a rapid and direct response to rainfall events. A tile drain outlet is located adjacent to a road culvert at this site. The road culvert transmits the surface runoff from the area north of the township road and discharges it to an open channel which originates on the south side of the road. This is the most upstream section of Nissouri Creek.

The sub-surface collector monitored here drains a smaller area. It discharges to the open channel through a separate culvert. The streamflow monitoring installation at Station N4 consisted of a 90° V-notch weir box which collected the discharge from the road culvert (see Photograph #1) and therefore measured only surface runoff. The water level in the weir box was proportional to flow rate through the culvert according to the formula for a 90° V-notch weir.

A stage plate affixed to the inside of the weir box was used to indicate water level which was referenced to an arbitrary datum, (a local bench mark served as the arbitrary datum). The weir had a maximum flow capacity of $0.2m^3/s$. It was constructed of wood and had a metal edge on the V-notch. The theoretical relationship between flow rate and water level for this device was verified by direct measurement. Water was pumped into the weir box and the discharge was timed and collected in a graduated container after a steady state water level was obtained. The theoretical stage discharge curve for this device is illustrated in Figure 4.2.

Photograph #2: Station N3 Monitoring Installation

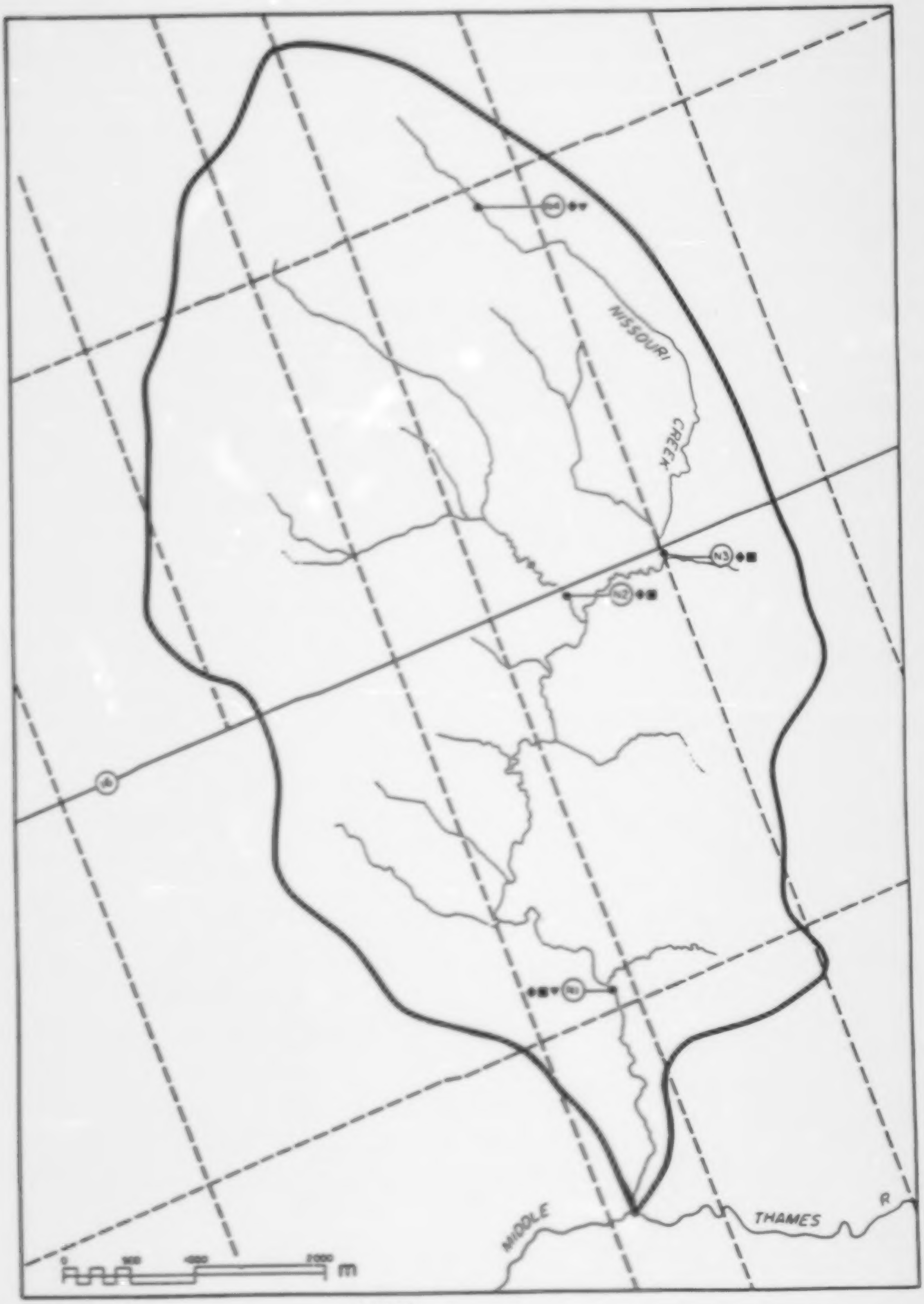

N4
MISSOURI CREEK
N3
N2
16
N1
MIDDLE THAMES R
0
500
1000
2000
m

FIGURE 4.1

Flow Monitoring and Surface Water Sampling Sites

LEGEND
TOWNSHIP ROADS
16 COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
N3 SAMPLING STATIONS
◆ AUTOMATIC WATER SAMPLER
■ WATER LEVEL RECORDER
▼ FLOW METER

Figure 4.2 Station N4 Stage/Discharge Curve

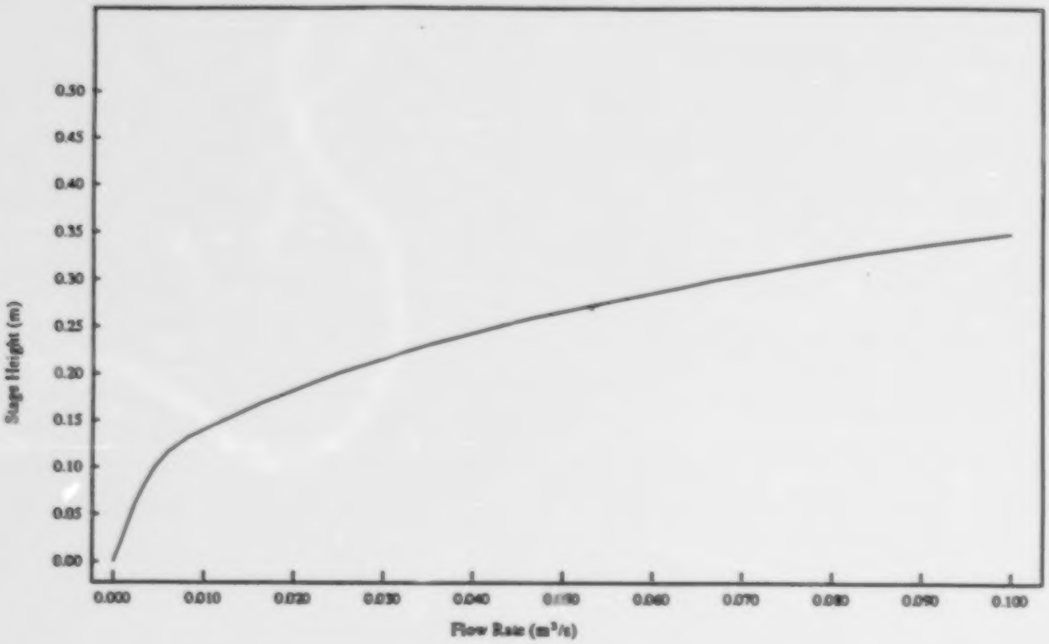
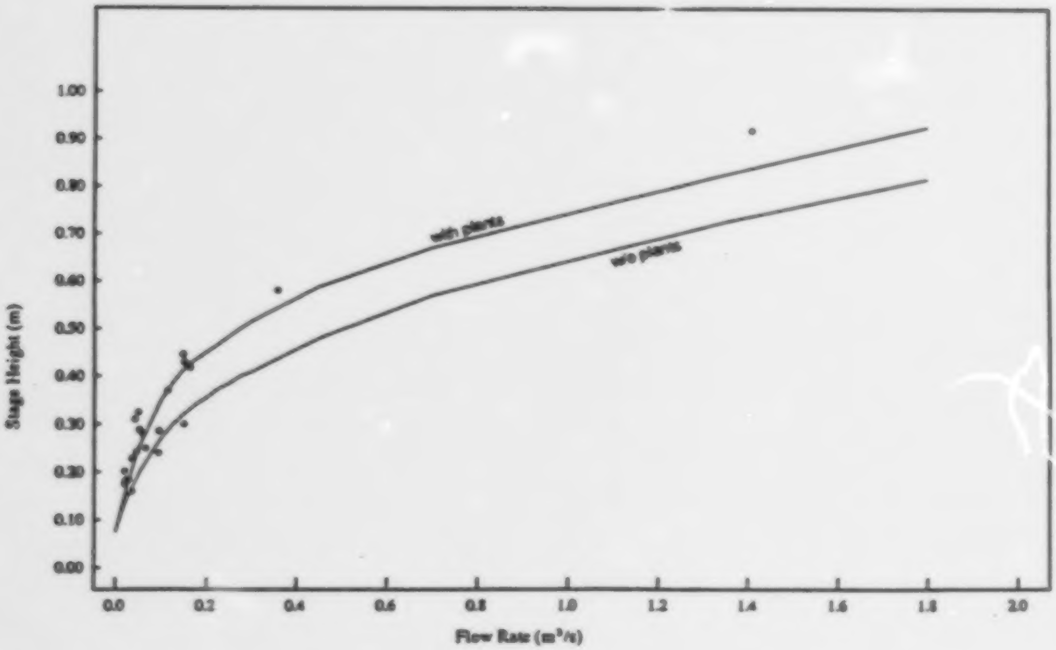


Figure 4.3 Station N3 Stage/Discharge Curve



An ISCO model 1870 recording flow meter was installed in a weather tight equipment shelter near the weir box. The flow meter was programmed to measure water level above the bottom of the V-notch and to convert that water level to a flow rate according to the theoretical equation for a 90° V-notch weir. This instrument was also used to signal and "trigger" a sequential water sampler installed at this site (see Section 4.3.1). This equipment was initially installed on 17 April 1984 and was operated during the ice-free seasons throughout the study. Table 4.1 lists the period of operation at this station. During the first month of operation, a Stevens F type water level recorder was used at this site.

Station N3 (see Figure 4.1) was located near the mouth of the eastern branch of the drainage system which drains an area of about 476 hectares in addition to the N4 drainage area. The instrumentation was located at on Oxford County Road #16 overpass beside a deep channel. Dense weed growth distorted the stage/discharge relationship at this station in 1984 and so a raised artificial control was placed in the channel on April 12, 1985. Concrete blocks were buried across the streambed downstream of the old stage plate and stilling well inlet. A second stage plate was located near the artificial control and has been correlated with stage heights from the original plate. Both stage plates were referenced to a nearby bench mark.

A Guelph-type shelter housing a Stevens A-71 type water level recorder was set atop an inverted 0.800m HEL-COR pipe buried into the west creek bank to act as a stilling well (see Photograph #2). This stilling well was fitted with an auxilliary inlet and valves for flushing. This station was operated during ice free periods as indicated in Table 4.1.

The N3 installation was checked routinely (every 2 weeks) and serviced if necessary. It required very little adjustment. The stilling well was flushed ocassionally to expel sediment from the inlet pipe.

A stage/discharge relationship was established for this site from repeated flow measurement. Flow measurements and observed stage plate water levels appear in Table 4.2 and the relationship obtained appears in Figure 4.3. Despite installation of an artificial control section it was found that adjustments to the stage/discharge relationship were still necessary to account for plant growth during the late spring and summer periods. Two stage/discharge curves were developed for this site; one for times

Photograph #3: Station N2 Monitoring Installation

TABLE 4.1 PERIOD OF OPERATION OF AUTOMATIC STREAMFLOW MONITORING STATIONS

Station #	Period of Operation	Instrument Type
N1	June 19, 1984 - December 22, 1986	Stevens A-71 Recorder, ISCO 1870 Flow Meter
N2	June 18 - December 21, 1984	Stevens A-71 Recorder
	April 11 - December 4, 1985	Stevens A-71 Recorder
	March 26 - December 22, 1986	Stevens A-71 Recorder
N3	June 19 - December 21, 1984	Stevens A-71 Recorder
	April 12 - December 4, 1985	Stevens A-71 Recorder
	March 26 - December 22, 1986	Stevens A-71 Recorder
N4	May 17 - June 17, 1984	Stevens F-Type Recorder
	June 17 - December 21, 1984	ISCO 1870 Flow Meter
	April 12 - December 4, 1985	ISCO 1870 Flow Meter
	April 2 - December 22, 1986	ISCO 1870 Flow Meter

TABLE 4.2 STREAMFLOW MEASUREMENTS, 1984-1986

Station	Date	Stage Ht. (m)	Flow Rate (m^3/s)
N1	18/05/84	0.187	0.147
	18/05/84	0.195	0.131
	08/06/84	0.232-0.240	0.443
	30/11/84	0.210	0.257
	12/12/84	0.278	0.647
	21/12/84	0.230	0.283
	12/04/85	.334	0.458
	22/05/85	.230	0.105
	27/05/85	.280	.257
	19/06/85	.340	.452
	04/07/85	.220	.054
	08/07/85	.270	.164
	12/07/85	.325	.290
	12/07/85	.300	.218
	24/07/85	.211	.039
	26/08/85	.440	.864
	05/11/85	.534	2.18
	06/11/85	.430	.922
	08/01/86	.300	.386
	04/03/86	.260	.168
	13/03/86	.490-.498	1.90
	22/04/86	.370	.835
	11/09/86	.445-.455	1.08
	25/09/86	.318	.334
	05/11/86	.292	.257
N2	18/05/84	.143	.063
	08/06/84	.160	.079
	06/07/84	.390-.368	.288
	01/11/84	.078	.031
	12/12/84	.250	.194
	12/04/85	.218	.129
	27/05/85	.148	.117
	19/06/85	.205	.142
	08/07/85	.055	.034
	24/07/85	.016	.010
	24/10/85	.203	.062
	05/11/85	.500	.386
	06/11/85	.390	.196
	22/04/86	.416	.178
	11/09/86	.380	.281
	25/09/86	.108	.071

TABLE 4.2 STREAMFLOW MEASUREMENTS, 1984-1986 (cont'd.)

Station	Date	Stage Ht. (m)	Flow Rate (m^3/s)
	05/11/86	.094	.072
	16/12/86	.112	.0775
N3	18/05/84	.160	.036
	08/06/84	.240	.094
	06/07/84	.890-.945	1.410
	06/11/84	.325	.050
	15/11/84	.430	.151
	30/11/84	.310	.043
	12/04/85	.286	.095
	22/05/85	.183	.022
	27/05/85	.185	.029
	19/06/85	.370	.115
	04/07/85	.202	.020
	08/07/85	.228	.036
	24/07/85	.175	.020
	24/10/85	.289	.052
	05/11/85	.580	.358
	06/11/85	.418	.164
	22/04/86	.300	.150
	11/09/86	.446	.148
	25/09/86	.280	.060
	05/11/86	.242	.046
	16/12/86	.250	.065
N4	18/05/84	.161	.000002

when there was significant biomass in the channel, and one for times when biomass was minimal. Flow rates were determined from water level records using one of these curves or an intermediate value for transition periods when plant growth or die off was most active. This method resulted in realistic flow rates when total daily flows were compared with the same from station N2.

Station N2 was located on the main tributary of Nissouri Creek at a more westerly Oxford County Road #16 overpass downstream of a drainage area of 830 hectares. This station was similar to N3 in that it consisted of a Stevens A-71 water level recorder atop a stilling well connected hydraulically to the creek upstream of a natural control point (see Photograph #3). The stilling well used here was the same well used in PLUARG related studies.

The period of operation of this station appears in Table 4.1. The flow measurements made at this site are included in Table 4.2 and the stage/discharge curve is illustrated in Figure 4.4. The well was occasionally flushed and the water level recorder was checked routinely (at least every 2 weeks). This installation was very stable, demonstrating no significant stage shifts during the course of the study.

Station [illegible] was the most downstream monitoring location. The runoff measured at this site drains most of the watershed (about 3,090 hectares). The flow monitoring instrumentation at this station was equipped to operate continuously throughout the year. This site was used in the PLUARG study and flow records are available from April 1975 to November 1977 (PLUARG, 1978e).

A stilling well and shelter, identical to that at N3, was located on the northwest corner of the bridge on Concession 14, Lot 11 (see Photograph #4). The stilling well inlet was upstream of a natural control point in the stream. A stage plate was affixed to the concrete bridge abutment and was referenced to the same bench mark used in the PLUARG study.

The equipment shelter and inlet pipe to the well were electrically heated to ensure continuous winter operation. Water level was recorded with a Stevens A-71 water level recorder, and flow rate was recorded with an ISCO Model 1870 flow meter. The ISCO flow meter was used to signal and trigger the automatic sequential water sampler at this

Photograph #4: Station N1 Monitoring Installation

Figure 4.4 Station N2 Stage/Discharge Curve

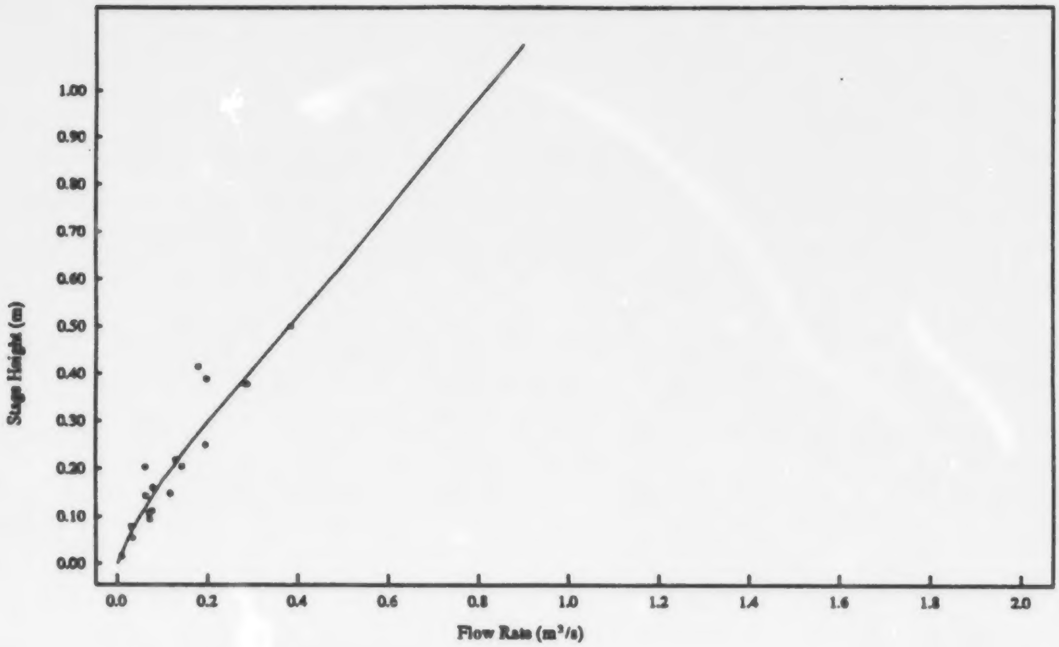
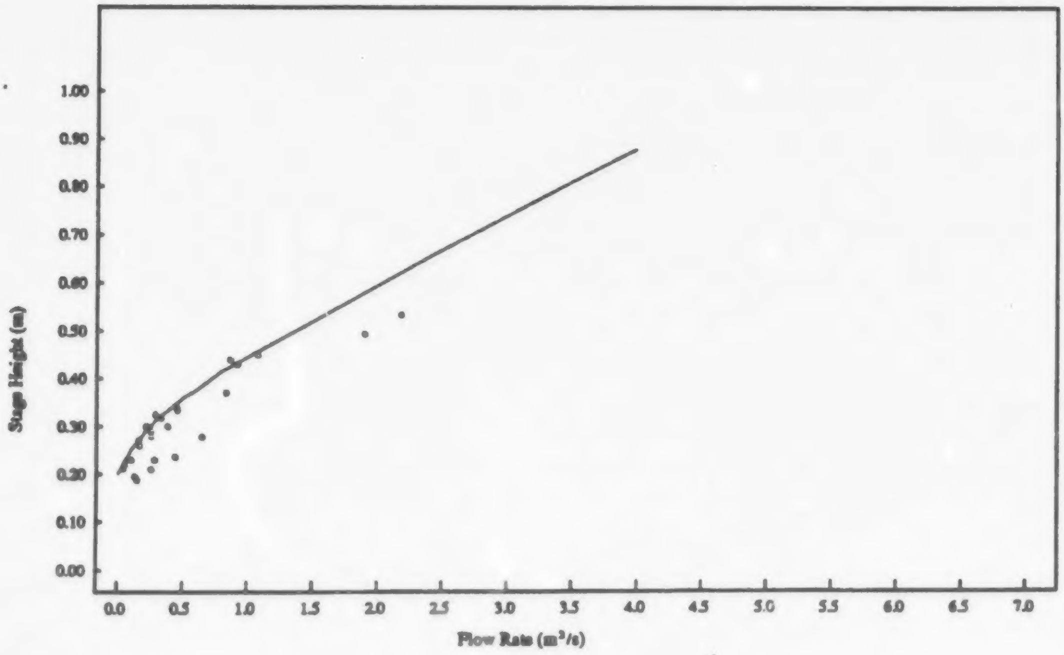


Figure 4.5 Station N1 Stage/Discharge Curve



station, as well as providing a backup flow record. This installation was in continuous operation from 19 June 1984 until 22 December 1986 (see Table 4.1).

Flow measurements were made at this site on several occasions to improve and upgrade the stage/discharge curve. The relationship was found to be quite different from that determined in the PLUARG study and it was observed to shift annually during this study. Table 4.2 and Figure 4.5 list flow measurements and illustrate the observed stage/discharge relationship respectively. All of the flow rate measurements made from 1984 to 1986 are shown in Figure 4.5. Only the 1986 stage/discharge curve has been shown. The stage shift from 1984 to 1985 was quite pronounced, in the order of 10 cm, while the shift from 1985 to 1986 was minimal at about 2 cm.

In terms of performance the flow meters and water level recorders operated quite reliably. The Stevens A-71 water level recorders operated trouble-free throughout the entire study with one exception. The Station N2 recorder malfunctioned for a short period in 1985 probably due to an overwound clock. The ISCO 1870 flow meters also operated reliably but required minor recalibration on a regular basis (ie. monthly) and occasional cleaning of the bubbler tubes.

Tables 4.3 and 4.4 list summary information for the four streamflow monitoring sites including maximum and minimum flow rates for the period of record as well as monthly total flows and annual total runoff for Station N1 for 1985 and 1986. The 1984 record has not been analyzed in detail, nor have adjustments or corrections been made for missing records or stage shifts. The 1984 monitoring period was used as a period for 'trouble shooting' and establishment of practices and protocols and was not used in modelling. We therefore provide no detailed analysis of this period.

Actual daily total streamflow for the 1985-86 period of record are included in Appendix C. Figures 4.6 to 4.9 illustrate daily total streamflow for all four stream monitoring sites.

4.2.2 Groundwater

Three piezometer nests were installed in the Nissouri Creek Watershed during the study at the locations indicated in Figure 4.10. Each nest consisted of three piezometers

TABLE 4.3: MONTHLY AND ANNUAL STREAMFLOW SUMMARY, 1985-86

Station #		N1	N2	N3	N4
		Stream Flow			
		($m^3 \times 10^6$)	($m^3 \times 10^6$)	($m^3 \times 10^6$)	(m^3)
Period					
1985 -	January	2.19	-	-	-
	February	6.28	-	-	-
	March	6.62	-	-	-
	April	2.73	-	-	-
	May	.249	.090	.053	8.66
	June	.492	.123	.134	910.0
	July	.249	.051	.050	93.7
	August	.284	.059	.048	70.7
	September	.327	.063	.049	18.6
	October	1.03	.270	.181	135.5
	November	2.58	.624	.473	407.0
	December	1.44	-	-	-
Annual Total		**24.47**	-	-	-
1986 -	January	1.31	-	-	-
	February	.798	-	-	-
	March	2.97	-	-	-
	April	.829	.220	.189	62.8
	May	.589	.198	.134	184.0
	June	.389	.117	.091	219.0
	July	.375	.112	.131	222.0
	August	.375	.094	.110	300.0
	September	1.35	.407	.371	461.0
	October	1.71	.412	.308	146.0
	November	.855	.213	.205	35.6
	December	0.96[2]	.348[2]	.332[2]	82.5
Annual Total		**12.51**	-	-	-

- not available

[2] - estimated for 31 days (decommissioned on December 21)

TABLE 4.4 STREAMFLOW EXTREMES, 1985-1986

Station	Maximum Instantaneous Flow Rate (m^3/s)	Minimum Instantaneous Flow Rate (m^3/s)	Date
N1	19.45		Feb. 24, 1985
		.02	Aug. 4, 1985
	6.27		March 19, 1986
		.05	July 11, 1986
N2[1]	.606		Nov. 10, 1985
		.004	Aug. 4, 1985
	.886		Sept. 30, 1986
		.009	July 11, 1986
N3[1]	.872		Nov. 10, 1985
		.004	Aug. 4, 1985
	2.03		Sept. 30, 1986
		.019	July 1, 1986
N4[1,2]	.055		June 17, 1985
		0	Aug. 4, 1985
	.042		July 18, 1986
		0	July 11, 1986

[1] - April - December only

[2] - surface runoff only

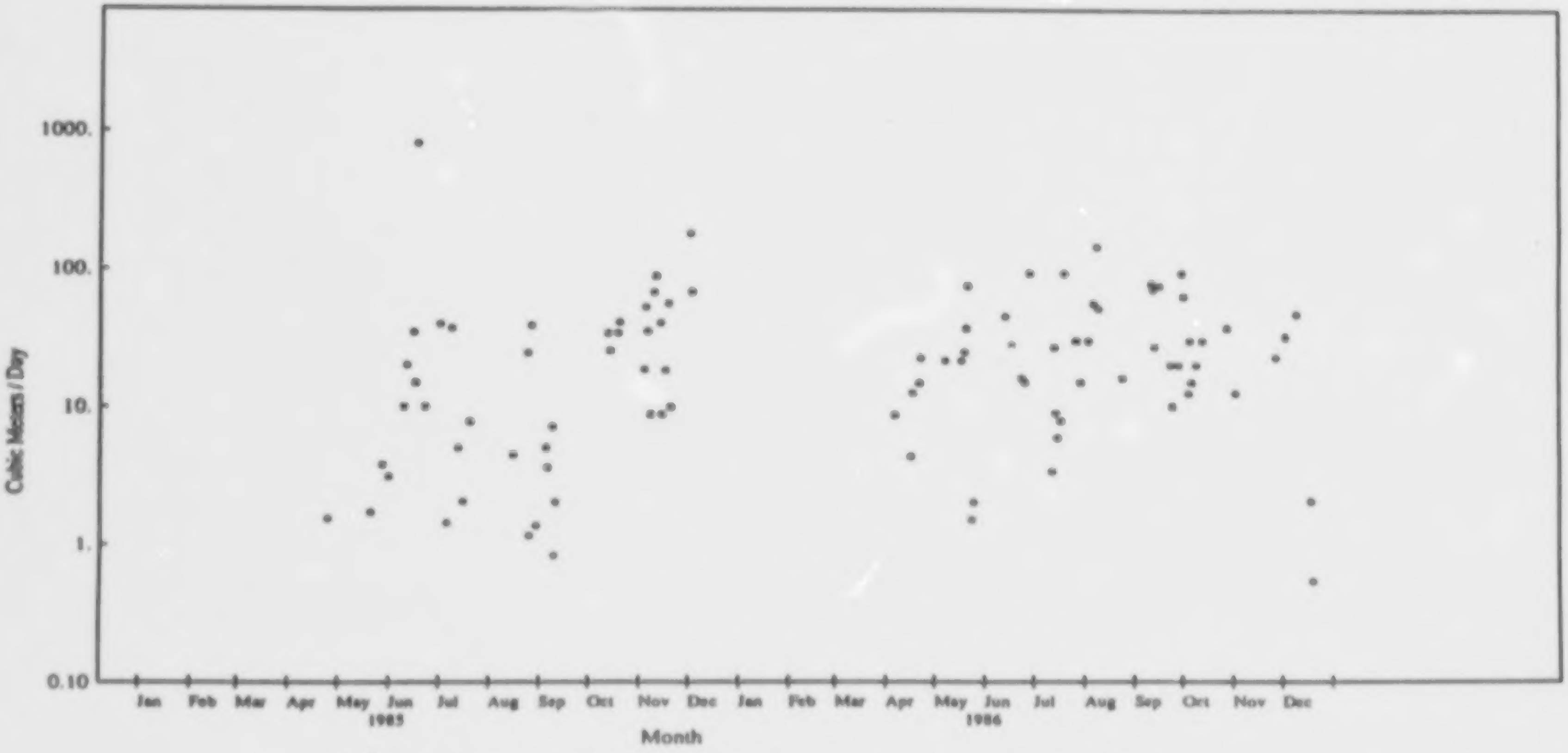


Figure 4.6 Station N4 Observed Total Daily Surface Runoff,85-86

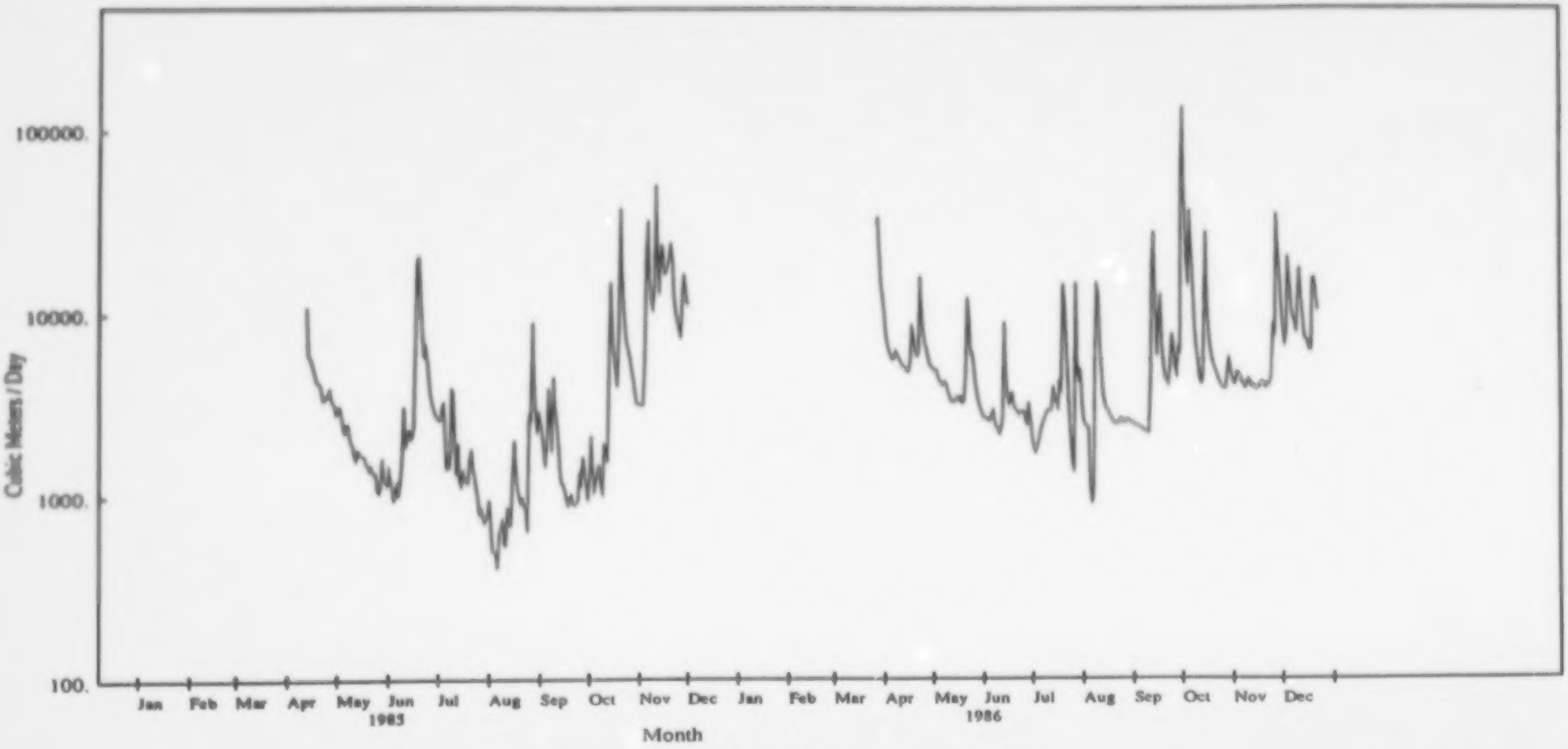


Figure 4.7 Station N3 Observed Total Daily Flow, 85-86

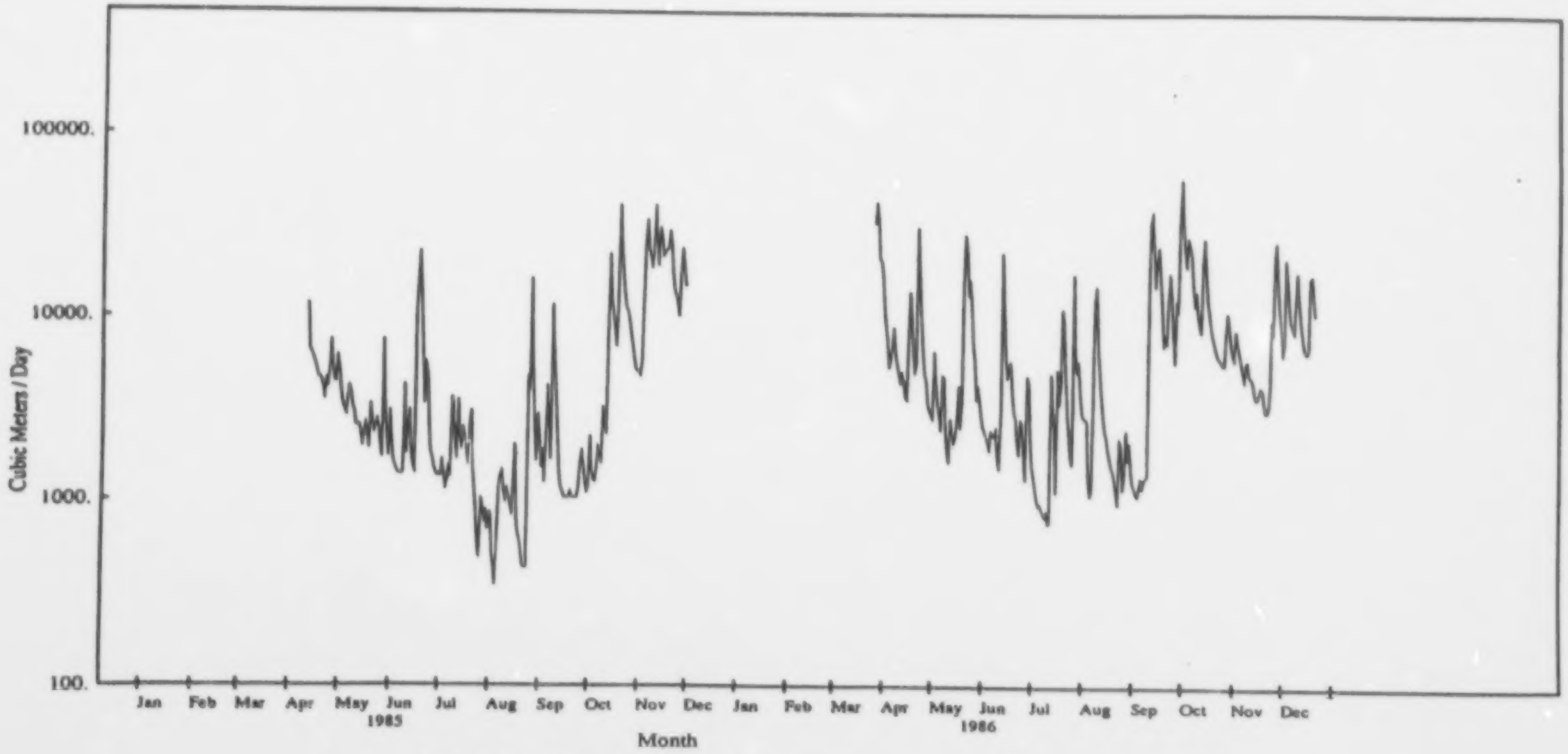


Figure 4.8 Station N2 Observed Total Daily Flow, 85-86

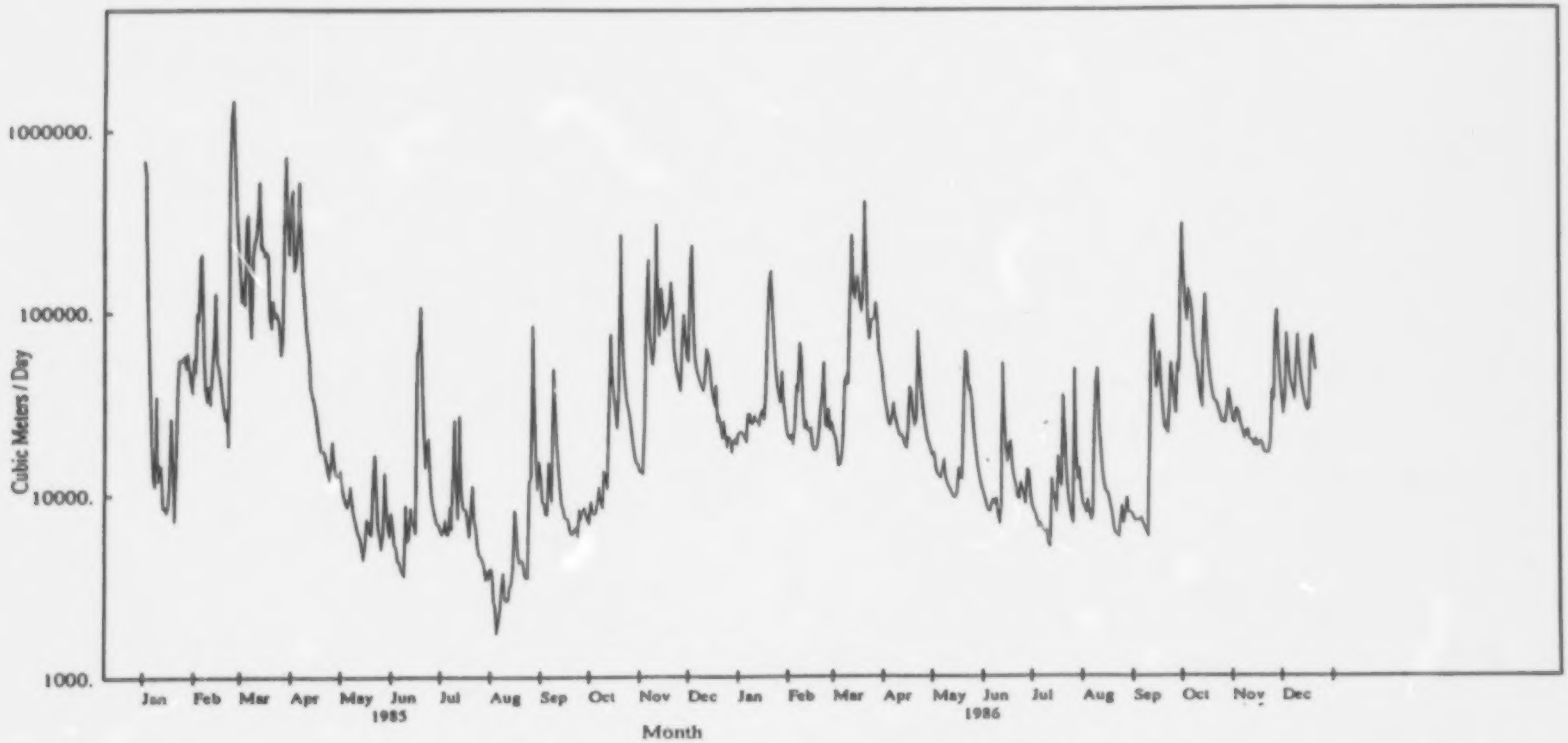


Figure 4.9 Station N1 Observed Total Daily Flow,85-86

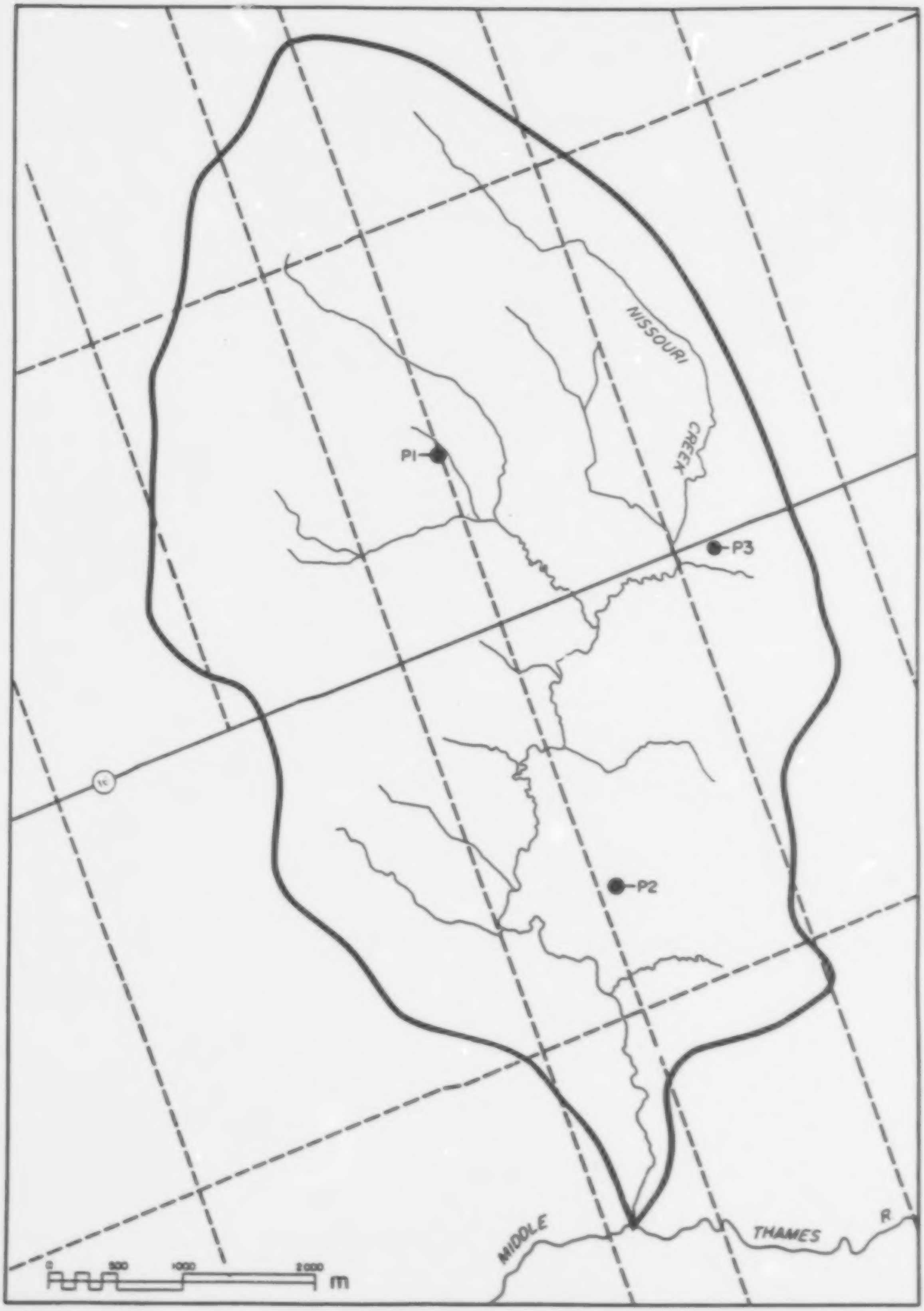

NISSOURI CREEK
P1
P2
P3
16
MIDDLE THAMES R
0 500 1000 2000 m
LEGEND
TOWNSHIP ROADS
16 COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
P2 PIEZOMETRIC NEST

FIGURE 4.10

Location of Piezometer Nests

extending to depths of 1.2, 1.8 and 2.4 metres. The piezometers are made of 1 1/2" polypropylene pipe and 0.25mm slotted PVC well screens (0.6m in length) capped at the bottom and top. The wells were packed with clay above the top of the slotted portion to eliminate contamination of groundwater samples by seepage from the surface layers.

Two piezometer nests were installed on 14 September 1984 and a third was installed on 3 July 1985.

The piezometers were primarily installed to allow for groundwater sampling. However, groundwater levels were recorded in the piezometers as a general indication of the amount of groundwater storage later in the study. Observed groundwater levels are listed in Appendix C. Groundwater quality is discussed in Section 4.3.

4.2.3 Tile Drains

Four selected tile drain outfalls have been included in the hydrologic monitoring. The area drained by each sub-surface collector and the location of the outfall sites are identified on Figure 4.11. Tiles numbered T1, T3 and T4 drain areas which have largely been underlain with a systematic drain system and therefore all of the interflow component is transported via these collectors. Drain T2 provides drainage in a random pattern over a small area.

Spot flow measurements were made at these four outfalls on a variable schedule. Individual observed flow rates are listed in Appendix C. Most tile drains were observed to flow continuously; however, drain flow decreases rapidly within 48 hours following a precipitation event. This information was used in model evaluation to assess the relative contributions and timing of tile drain flow.

4.2.4 Time of Travel

Time of travel measurements were made on two occasions to allow for an approximation of stage-area-volume-discharge relationships for watershed reaches. These relationships are required input for HSPF (called F-Tables) and are used to route pollutants and to determine instream physical process rates.

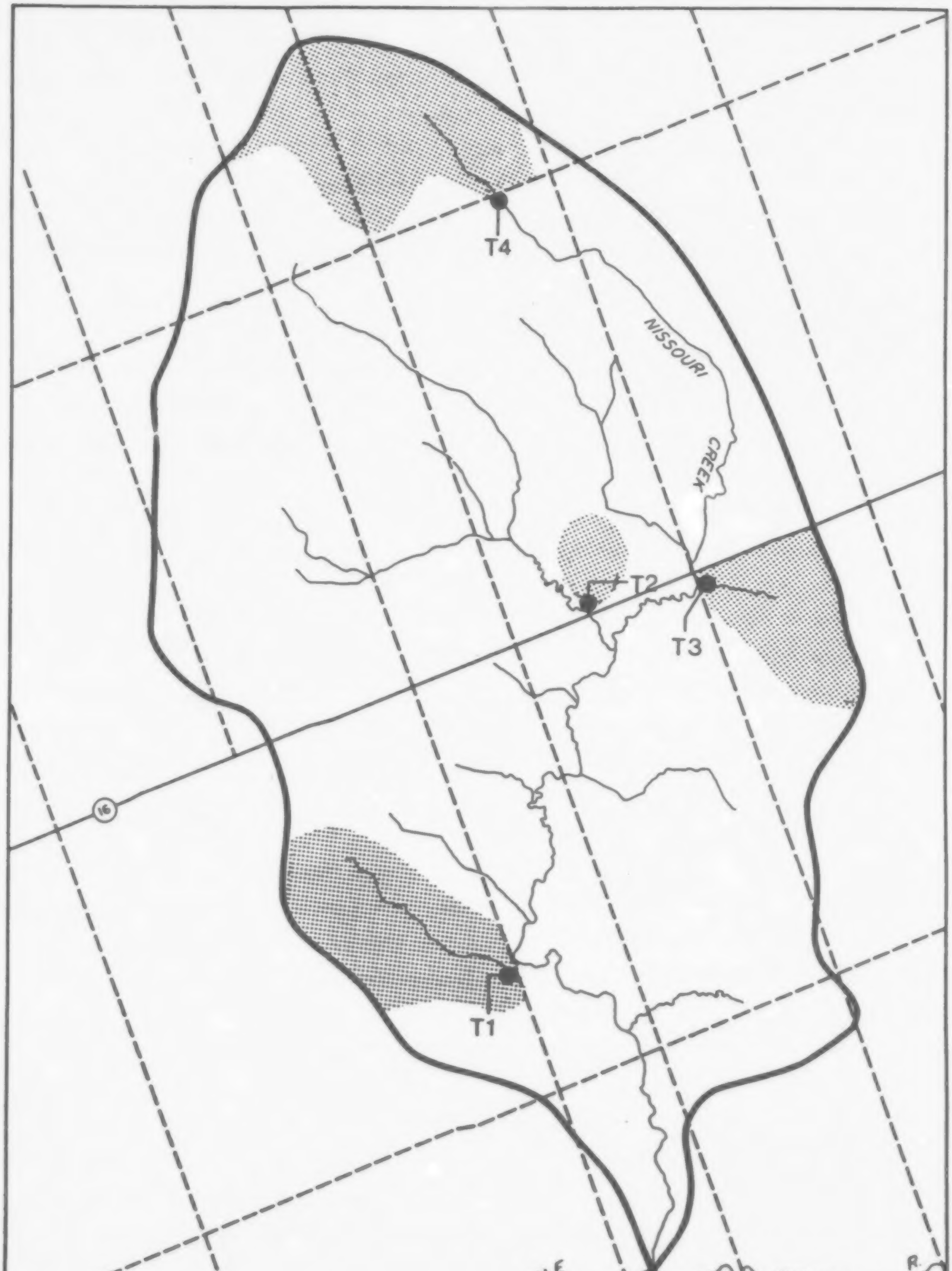

T4
NISSOURI
CREEK
T2
T3
16
T1
MIDDLE
THAMES
R.
0
500
1000
2000
m

FIGURE 4.11

Location of Tile Drain Sampling Sites

LEGEND

— — — TOWNSHIP ROADS
—⑯— COUNTY ROADS
—·—·— SUBSURFACE WATERSHED BOUNDARIES
—— [illegible]
●— T2 TILE DRAIN OUTLET

Table 4.5 lists the pertinent information gathered from the two time of travel measurements. F-tables were developed by estimating time of travel between monitoring stations for the flows which occurred during measurements and at other flows by extrapolation using the stage/discharge curves at the monitoring stations. The resultant F-tables are approximate but sufficiently accurate for the purpose of this study.

4.3 Water Quality

4.3.1 Surface Water Quality

Surface water sampling and analysis, in conjunction with streamflow monitoring, is the primary method by which total soil, phosphorus and atrazine mass transport has been accounted.

Surface water samples were collected at the four streamflow monitoring sites, N1 to N4 (See Figure 4.1), thus allowing calculation of loadings for events and interevent periods for catchment scales ranging from 170 to 3090 hectares. Each site was equipped with an automatic sequential water sampler with a shrowded inlet tube fixed in the active portion of the streambed.

Samplers were of the ISCO 2100 or Manning type which can be programmed for various sampling schemes. These instruments proved to be highly reliable in this study. At station N1 an ISCO 2100 sampler was interfaced with an ISCO 1870 flow meter. The flow meter was set to "trigger" the sampler to take samples on a flow proportional basis. That is, a discrete subsample was taken after each time that a designated amount of water had been measured to have passed the station. This scheme results in the collection of a higher number of equal volume subsamples during the peak periods of the hydrograph. Mass flux for any parameter for the entire event is then calculated by simply multiplying the flow proportional composite sample concentration by the total flow observed. Pollutographs or chemographs cannot be constructed from this information but sample analysis costs are minimized without sacrificing loading data.

The ISCO flow meter at station N1 was programmed with the stage/discharge curve for that site (see Figure 4.5) so that direct and continuous estimation of flow rate was

TABLE 4.5 TIME OF TRAVEL MEASUREMENTS

Date	Dye Dumped At	Monitored At	Distance Travelled (m)	Time to Centroid (h)	Average Flow Rate at Monitoring Site (m/s)	Volume of Reach (m^3)
10/06/86	Concession 14 bridge	Stn. N1	3,550	6.0	0.22	4320-4970
16/12/86	Meteorological Station	Stn. N3	3,000	9.0	0.033	972-1135

achieved. The program for this site was modified annually to account for changes in the stage/discharge relationship. All equipment was powered by 110 volt service and was heated by cables and light bulbs during the winter months for full year operation. A similar scheme was employed at station N4. At N4, an ISCO 1870 was programmed with the V-notch weir equation and used to trigger an ISCO 2100 sampler to take samples from the weir box. This scheme was most applicable at this site due to the rapid response and intermittent nature of surface runoff. All equipment was battery powered and operated during ice-free periods only.

Stations N2 and N3 were equipped with ISCO 2100 or Manning samplers programmed to take up to 24 discrete samples on a regular time interval over the course of an event. Following the event, the mass of flow represented by each discrete sample was determined from the water level recorder chart. One to three composite samples were then prepared from the discrete samples on a flow proportional basis. That is, a subsample volume was taken from each discrete sample where the volume of subsample was proportional to the mass of flow represented by that sample. In effect, this scheme produces flow proportion samples as at stations N1 and N4.

Approximately fifteen runoff events were sampled in this manner each year. On one or two events per year a set of discrete samples collected at stations N1, N2 and N3 were submitted for analysis. These samples were used to construct chemographs for the event. An example chemograph for the event of June 17-19, 1985 is presented in Figure 4.12.

Interevent samples were taken at least once per month at stations N1, N2 and N3 throughout the study and these were used to estimate baseflow loadings for key paramaters. These samples were grab sampled from the centre of the stream at each station. All samples were preserved at 4°C and were delivered to the MOE laboratory (Rexdale) and the OMAF pesticides laboratory (University of Guelph) within 48 hours of collection. No chemical preservations were used. All standard handling protocols were observed. The MOE laboratory analyzed the samples for the following parameters:

- conductivity,
- potassium,
- chloride,

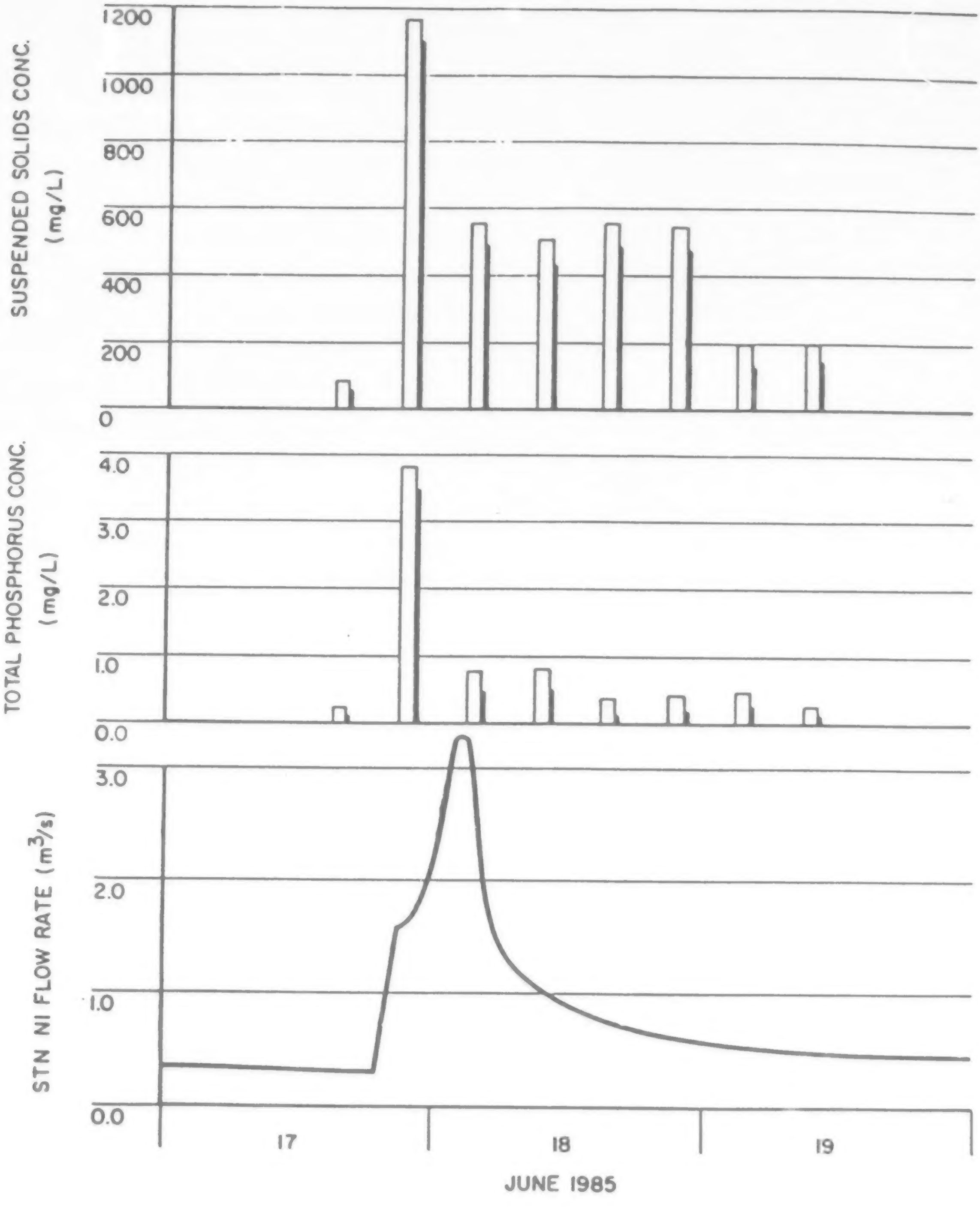


FIGURE 4.12 Event Hydrograph and Chemograph (June 1985)

- sulphate,
- particulate residue,
- total phosphorus,
- soluble reactive phosphorus,
- unfiltered total Kjeldahl nitrogen,
- ammonia,
- nitrates, and
- nitrites.

This study used only the suspended sediment and phosphorus data from this group. Remaining parameters were analysed for historical purposes.

The OMAF laboratory analysed samples for atrazine and desethylatrazine. Other pesticides were identified in some samples and further determination of a variety of pesticides is still possible using the gas chromatograph scans.

The results of suspended solids, total phosphorus and atrazine analyses for the four surface water stations were used to calculate daily loadings by multiplying concentrations by streamflow. Some composite samples represented runoff event periods ranging from a few hours to two days. In these cases an estimate was made of the period represented by a sample and a daily load was calculated by combining two or more short duration loads or using a fraction of a long duration composite load estimate. The result of this analysis is a set of time series records of daily loadings at the four stations for suspended sediment, total phosphorus and atrazine. Typically, 60 to 70 daily loads were calculated per year with a higher frequency of data in the summer months. Fewer daily volumes are available at station N4 since this station measured only surface runoff and surface runoff events were infrequent. More than half of all actual significant runoff events have been included in our sampling thus more than half of the actual annual loadings were observed. These data are used to compare with and evaluate predicted loadings from modelling.

Appendix D contains a listing of 1985 and 1986 estimated daily loadings of suspended solids, total phosphorus and atrazine. Table 4.6 summarizes the extremes of daily loads observed for these three parameters for the same period.

TABLE 4.6 SUMMARY OF DAILY LOADING EXTREMES FOR SUSPENDED SOLIDS, TOTAL PHOSPHORUS AND ATRAZINE

Surface Water Quality Station	Catchment Area (ha)	Suspended Solids Minimum Daily Load (kg)	Suspended Solids Maximum Daily Load (kg)	Total Phosphorus Minimum Daily Load (kg)	Total Phosphorus Maximum Daily Load (kg)	Atrazine Minimum Daily Load (kg)	Atrazine Maximum Daily Load (kg)
N1	3,090	5.6	82,604	.09	244	.001	2.47
N2	830	0.4	13,920	.02	62.0	.001	.252
N3	640	1.0	12,106	.01	45.7	.001	.820
N4*	170	.02	237.4	.00004	3.18	.0006	.062

*Surface runoff only

Some trends are apparent in the relative proportions of soluble reactive phosphorus (SRP) and total phosphorus (TP) observed in tile drain samples and in stream water samples. Table 4.7 summarizes average total and soluble reactive phosphorus concentrations found in Station N1 samples as well as the four selected tile drains. Station N1 phosphorus data is also divided into event and interevent time periods. All tile drain runoff is event related. The SRP/TP ratio is listed for all sites. Clearly, the majority of Station N1 phoshorus is not the soluble reactive form and it can be assumed that most of the non-soluble reactive phosphorus is in a particulate form, either attached to soil or bound with organic material.

During the interevent periods when streamflow originates from groundwater and tile drainage the SRP fraction dominates the total phosphorus in the receiving water. Since the SRP fraction does not include all of the soluble phosphorus (i.e., other forms of soluble phosphorus include dissolved organic phosphorus and polyphosphates) it can be assumed that the SRP values reported here are underestimates of total soluble phosphorus. Therefore, during interevent periods the stream phosphorus is largely in a soluble form.

During event periods when surface overland runoff occurs, the SRP/TP ratio is much lower indicating that much more particulate phosphorus is present.

The tile drain SRP/TP ratio varies from drain to drain with a weighted average of 0.50. This value clearly matches the interevent SRP/TP ratio of 0.53 for Station N1.

These trends are confounded by instream processes such as streambank erosion and resuspension of settled material as well as plant growth and die-off which tend to modify the partition between sub-surface soluble phosphorus supply and surface soil-attached and organic phosphorus supply.

A more definite link between stream water quality and meteorological events is presented in Section 5.7 upon review of modelling results.

Quality assurance/control studies were conducted in 1985 to assess the following factors:

- the potential for cross contamination between automatic sampler bottles during a sampling period,

TABLE 4.7 SUMMARY OF TOTAL AND SOLUBLE REACTIVE PHOSPHORUS FOR WHOLE WATERSHED TILE DRAINS, 1984-86

	Station NI	Tile Drain Outlets			
		T1	T2	T3	T4
# of Samples	133	39	15	40	47
Average Total Phosphorus Concentration (TP) (mg/l)	.305	.024	.069	.139	.064
Average Soluble Reactive Phosphorus Concentration (SRP) (mg/l)	.070	.009	.060	.091	.021
SRP/TP	.23	.39	.87	.65	.33
Interevent Average TP (mg/L)	.041	-	-	-	-
Interevent Average SRP (mg/L)	.022	-	-	-	-
Interevent SRP/TP	.53	-	-	-	-
Event Average TP (mg/L)	.396	-	-	-	-
Event Average SRP (mg/L)	.087	-	-	-	-
Event SRP/TP	.22	-	-	-	-

- the rate of biochemical decay in atrazine samples during a sampling period, and
- the potential for cross-contamination of samples in the automatic sampler caused by the sampler's delivery system.

In these tests, cross-contamination in the automatic samplers was found to be insignificant, while short-term atrazine sample stability was found to be adequate within the time frame of sample collection and delivery. A description of tests conducted and their results is presented in Appendix I.

4.3.2 Groundwater Quality

In order to assess the potential for contamination of groundwater by atrazine and to aid in estimating the rate of movement of atrazine to streams via baseflow, groundwater atrazine samples were taken from piezometers (see Figure 4.1D) on a regular basis. Results of groundwater atrazine analyses are listed in Appendix D. In summary of this data, atrazine was detected in 44 of 153 samples collected. Piezometer P1 (see Figure 4.10) had very low levels with only ten positive results out of 74 samples. The maximum concentration at this site was 0.22 ug/l at the 1.2 metre level. Piezometer P2 had 14 positive results out of 46 samples. The maximum level was 0.41 ug/l at the 1.8 metre level. Piezometer P3, located adjacent to the field selected for atrazine decay studies by MOE in 1985 had the highest atrazine levels. This site had 22 positive results out of 32 samples. The maximum concentration detected was 210 ug/l from the 2.4 metre level in mid July. A second high atrazine concentration of 42 ug/L was detected at this site two weeks later. Samples taken from the two shallower piezometers at this site did not contain abnormally high atrazine levels. One possible cause for the very high atrazine concentrations at this site is that atrazine may have moved through a soil fissure or 'macropore' near the piezometer and into the groundwater. An accidental spill near this area could also contribute to a high sporadic groundwater value.

These results indicate that the presence of atrazine in groundwater is relatively rare and generally low in concentration. All piezometers sampled are near cornfields and therefore are likely to be near atrazine applied areas. These results therefore represent the worst case. It is also apparent that atrazine is mobile in the soil column and can percolate in a soluble form to the groundwater zone. Groundwater is therefore a source of surface water contamination by atrazine. The relative contribution of atrazine from groundwater to the Nissouri Creek is discussed in Section 5.7 upon review of model predictions.

4.3.3 Tile Drain Outfall Quality

Tile drain outfall samples were collected frequently and analyzed as a means of estimating the importance of the sub-surface drainage network to soil, phosphorous and atrazine transport. Four selected tile drain outfalls (See Figure 4.11) were grab sampled following events. Appendix D contains summaries of water quality results for suspended solids, phosphorus and atrazine found in the selected drains.

The relationship and trends observed between soluble reactive phosphorus and total phosphorus has been discussed earlier. Suspended solids were detected at very low levels in tile drains on most occasions. However, high levels of 100.5 and 625 mg/L were detected in two different tiles in 1986. It is possible in these cases that there were soil fissures or drain cracks which allowed eroding soil to enter the sub-surface drainage network during surface runoff events. Average values were sufficiently low that it can be concluded that tile drain outflow is not a significant pathway for eroded soil except in extreme cases or where damage to the system has occurred.

Total phosphorus levels in tile drain outflow were generally low with minimum, average and maximum levels of 0.002, 0.045 and 1.51 mg/L respectively. Higher levels were found associated with high suspended solids concentrations following major storms indicating that some soil erosion into the drain had occurred. While total phosphorus levels in the tile drain outflow were relatively low, this pathway is a significant component of the total phosphorus flux during baseflow periods. The discussion of modelling results in Section 5.7 aids in placing this component into perspective.

Atrazine was found in 134 of the 144 tile drain outflow samples taken. This reinforces the earlier observation that atrazine is mobile in the soil matrix. Measured atrazine concentrations ranged from non-detectable to 85 ug/L. The majority of samples had atrazine concentrations below 5 ug/L. In general, atrazine concentrations rise substantially after May and remain higher through June and July than during the fall and winter months. Tile drain outflow is a significant pathway for atrazine movement to the watercourse, especially during the summer months. This fact will be reinforced in Section 5.7 upon review of modelling results.

4.4 Meteorology

Precipitation, which results in surface runoff and percolation through the soil column to the sub-surface drains and groundwater table is the primary driving force behind soil and agri-chemical migration. Other meteorological parameters affect rates of evaporation, snowmelt, soil temperature and infiltration rates, biochemical degradation rates, volatilization rates, and crop development. These are all important natural processes which affect the state of water, soil and chemical components in the watershed.

Meteorological parameters are highly variable, both spatially and temporally, necessitating intense monitoring. BEAK, therefore established a continuously recording weather station (Climatronics Inc.) in the watershed for the duration of the study at the site indicated in Figure 4.13. This station measured and recorded the following paramaters:

- rate of rain (and snow),
- total precipitation,
- wind speed and direction,
- evaporation,
- air temperature, and
- solar radiation.

Rate of rain was measured by a tipping bucket rain gauge and evaporation was measured using a Sierra Misco model 3004 wet bulb type of gauge. This latter instrument proved to be troublesome and unreliable. Evaporation records were eventually developed from long term records for the London area. All parameters (except evaporation and total precipitation) were continuously recorded on chart paper and on magnetic medium using a Climatronics Cassette Data Acquisition system. Total rainfall was recorded manually for each gauge on each service visit (about once every 10-14 days).

In addition to the weather station, two more rate of rain (tipping bucket) gauges were installed in the watershed (see Figure 4.13) to provide the spatial density necessary to

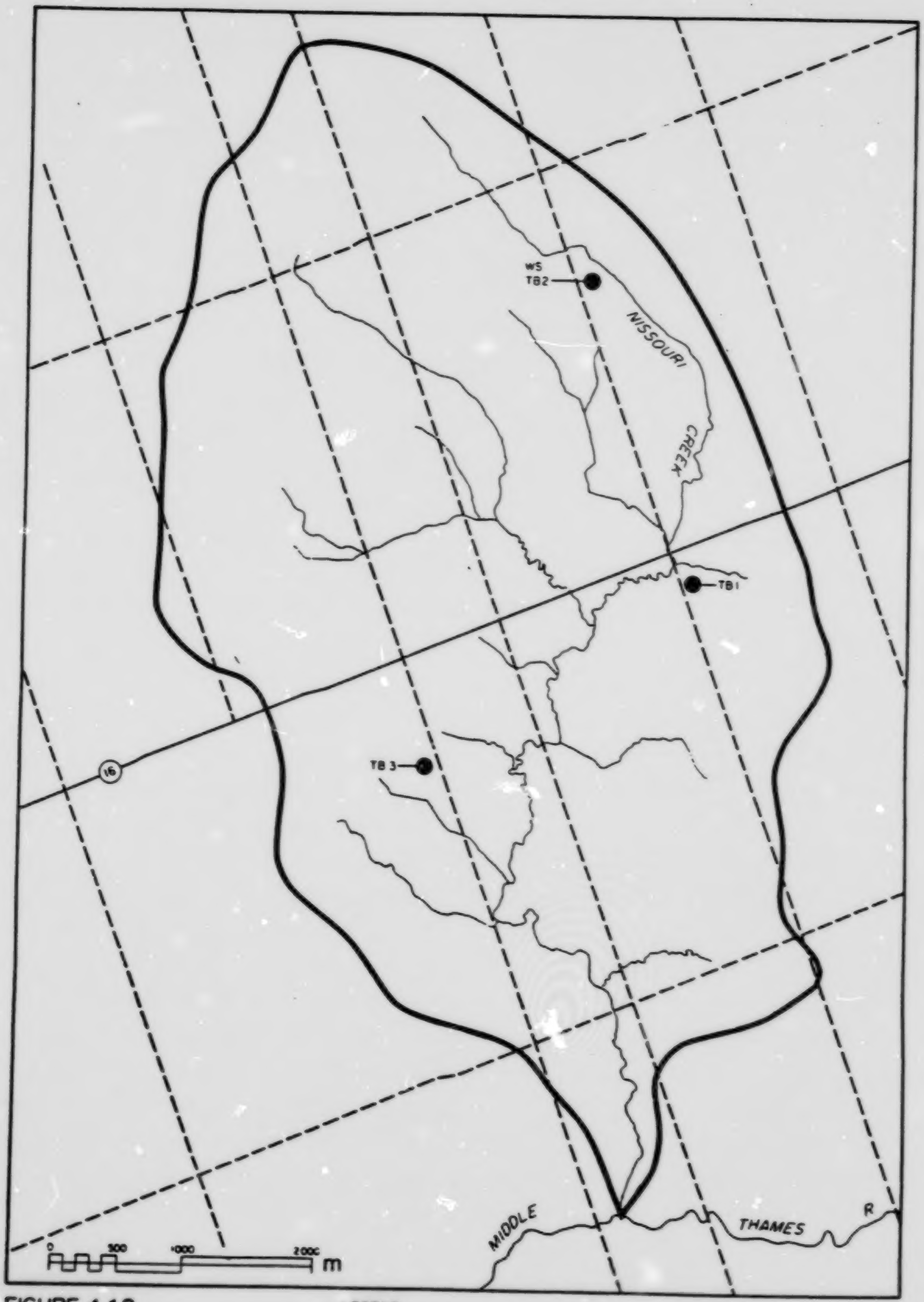

WS
TB2
NISSOURI
CREEK
TB1
TB 3
16
MIDDLE
THAMES
R
0
500
1000
2000
m
LEGEND
TOWNSHIP
COUNTY ROAD
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
TB 2 RAIN GAUGE
WS MAIN WEATHER STATION

FIGURE 4.13

Meteorological Instrument Sites

accurately estimate rainfall. Rainfall is often spatially very heterogeneous, especially during thunderstorms. Each rate of rain instrument was accompanied by a standard rain gauge for total precipitation measurement. Three other standard rain gauges were strategically located around the watershed as indicated in Figure 4.13 early in 1985 for the remainder of the field program.

The main weather station operated 12 months per year with a heated rain gauge to estimate snowfall rates. It is recognized that these gauges do not accurately capture snowfall for many reasons. The resultant record was used as an indication of snowfall frequency and was factored to reflect spring runoff volumes. All other rain gauges were removed during the winter months.

Instrument malfunctions were relatively infrequent. Some rate of rain data was lost due to mechanical breakdown and/or vandalism. The periods of record were filled by using the data from a nearby gauge. Vandalism resulted in the loss of the entire weather station in the summer of 1984. The instruments were replaced within sixty days and meteorological data from the London area AES (station #6144475) were acquired for substitution of the lost records. All other gaps in the record were filled with London airport weather data.

All rain gauges are subject to underestimation errors due to winds and edge effects. Tipping bucket gauges are subject to additional mechanical and/or calibration error. It was therefore necessary to adjust the rate of rain gauge records upwards to estimate snowfall rate. The method recommended by Goodison (1977) for snow catch estimation was used to correct the records compiled in this study. As a further refinement, the rate of rain gauge records were factored so that daily total rainfall agreed with that measured by the standard rain gauges.

Instruments were sited and installed to comply, as much as possible, with AES guidelines. Rate of rain gauges were recalibrated in BEAK's laboratory annually.

Table 4.8 summarizes the monthly and annual total precipitation for the three tipping bucket rain gauges for the 1985-86 period. Long term precipitation normals for Woodstock are also shown for comparison. Considerable discrepancy exists between gauges and in terms of the annual totals emphasizing the spatial and temporal variability

TABLE 4.8 PRECIPITATION DATA SUMMARY, 1985-1986

Month		Precipitation (mm)[1] TB-1	TB-2	TB-3	Long Term Normals (1950-81)[4]
1985	January	-	81.8	-	60.2
	February	-	39.7	-	49.9
	March	-	137.3	-	70.1
	April	57.6	48.0	54.3	76.2
	May	55.3	49.5	57.4	64.8
	June	93.8	97.7	103.0	82.0
	July	80.0	72.5	84.5	75.4
	August	114.0	77.6	105.0	88.4
	September	59.0	54.2	43.0	74.2
	October	130.0	110.0	92.3	73.7
	November	256.2	147.8	156.7	71.7
	December	186.1	149.6	149.6	74.9
Annual Total[3]		1,290	1,066	1,104	861.6
1986	January	-	13.8	-	60.2
	February	-	42.7	-	49.9
	March	34.8	33.3	33.3	70.1
	April	60.8	48.3	59.0	76.2
	May	620	70.8	66.1	64.8
	June	108.0	84.1	86.4	82.0
	July	124.0	108.0	114.0	75.4
	August	92.5	86.0	89.3	88.4
	September	215.0	167.0	177.0	74.2
	October	57.8	64.8	64.6	73.7
	November	31.5	31.9	34.8	71.7
	December[2]	94.0	78.9	104.0	74.9
Annual Total[3]		937.0	829.0	885.0	861.6

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[1] - all precipitation has been converted to water equivalent assuming snow density of 0.1. Snow catch has been corrected for undercatch and the entire record has been corrected to agree with standard rain gauges.

[2] - TB-1, TB-2 and TB-3 until December 21, 1986 only.

[3] - Annual totals for TB-1 and TB-3 have been calculated using TB-2 records for winter.

[4] - Woodstock AES station.

of this parameter. It is interesting to note that the observed precipitation in October and November of 1985 and September of 1986 were well above normal while precipitation for the winter of 1986 was below normal. Total precipitation over the 1985-86 period was about 18% above the long term normal for 1950 to 1981. More recent climate data shows higher annual rainfall in the 1980's, similar to the results observed here. Figure 4.14 illustrates the daily total precipitation recorded at the main meteorological station from 1985-86. The abnormally wet periods observed in the latter periods of 1985 and 1986 are clearly outstanding in this figure. Table 4.9 lists some extreme data for precipitation, air temperature and wind speed. Figures 4.15 to 4.17 illustrate daily average wind speeds, air temperatures and total daily solar radiation respectively for the same period. Time series meteorological information is listed in Appendix E.

4.5 Land Use

Land use within the Nissouri Creek Watershed is largely agricultural with about 13% in other uses. These other uses include roadways, residential lots, forested areas or swamp, and idle land. OMAF has mapped Oxford County land use using a field map system with 7 different categories and 12 non-system land uses. This scheme recognizes that agricultural land is subjected to cropping on a rotation basis. That is, a particular field can be planted with different crops in different years and lay fallow one in four or five years. This system is appropriate for use in long term assessments of the effects of agricultural activity on soil loss and agri-chemical migration over large areas where land use tends to remain the same on average. However, in this study, detailed information regarding crops and chemical usage on a farm by farm basis was necessary for accurate model calibration. Clearly, if fields normally planted in row crops were left fallow during one year of the study, then runoff would display a significant change in volume and chemistry from years when row crops existed.

BEAK undertook aerial surveys of the watershed in 1985 and 1986 to photograph the area in full crop canopy. Ground truthing was conducted at the same time and detailed maps of fields and crop type were prepared. This scheme was limited to three specific land use types including corn, other crops (mainly mixed grains and soybeans), and non crop areas (including pasture, idle, roads, residential, forest and swamp). Corn fields were clearly identifiable from the aerial photographs which had a scale of about 1:20,000.

Photograph #5: Aerial Photographs of Nissouri Creek Watershed Land Use

Figure 4.14 Daily Total Precipitation at Meteorological Station TB-2, 1985-1986

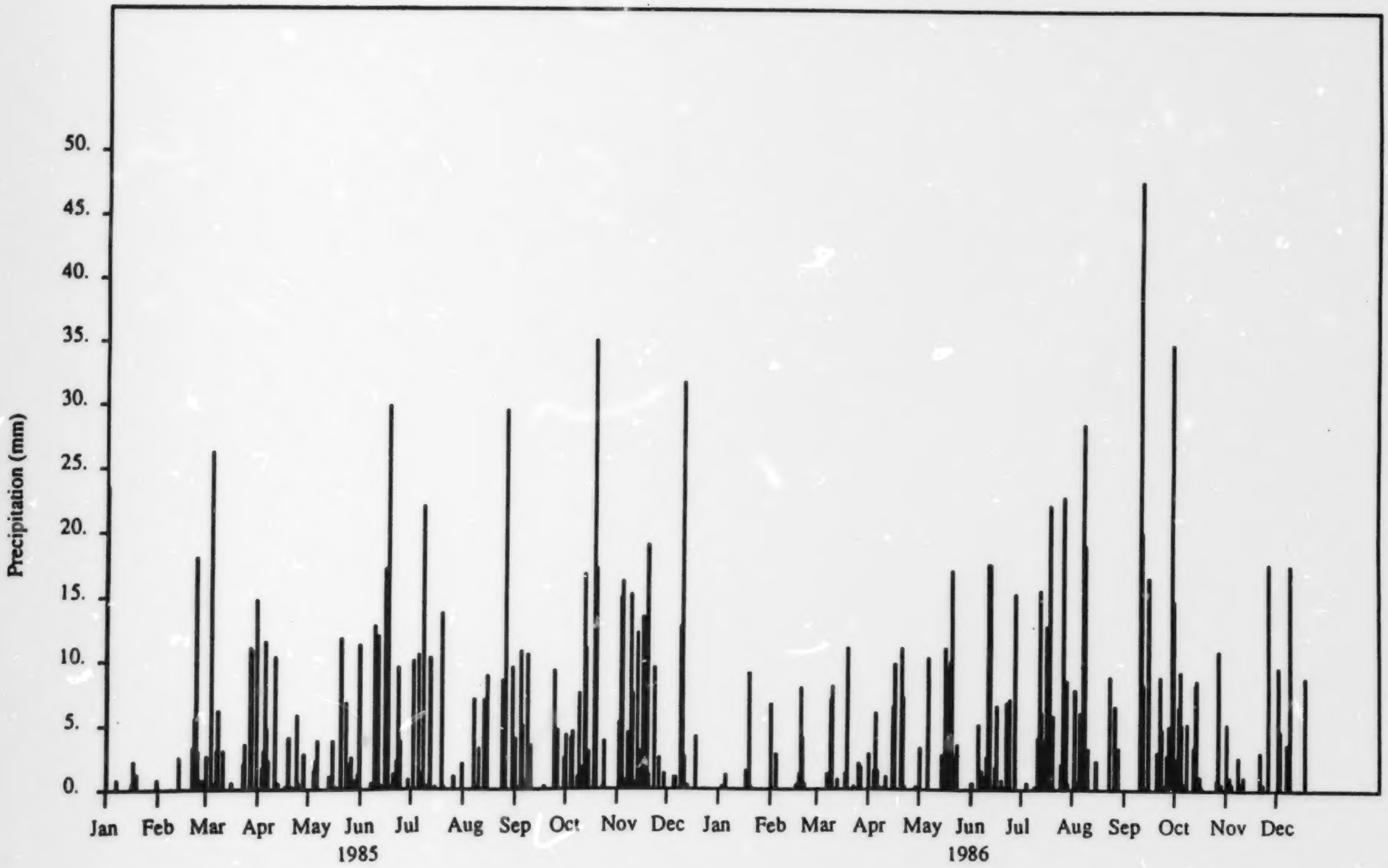


TABLE 4.9 EXTREME METEOROLOGICAL EVENT DATA, 1985-86

Precipitation:	
Maximum Rainfall - one day (mm):	1985 - 59.3 (Aug. 26) TB-1 1986 - 83.9 (Sept. 10) TB-1
Maximum Rainfall intensity (mm/hr):	1985 - 25.0 (Aug. 26) TB-1 and TB-3 1986 - 23.8 (Sept. 10) TB-1
Longest Period Without Precipitation:	1985 - 12 days (Feb. 1-12) 1986 - 14 days (Nov. 12-25)
Air Temperature	
Highest Temperature (°C):	1985 - 28.4 (Sept. 7) 1986 - 29.7 (May 29)
Highest Daily Average Temperature (°C):	1985 - 22.9 (Sept. 7) 1986 - 24.4 (July 18)
Lowest Temperature (°C):	1985 - -25 (Jan. 21) 1986 - -21.8 (Jan. 15)
Lowest Daily Average Temperature (°C):	1985 - -16.5 (Jan. 21) 1986 - -14.6 (Nov. 9)

Figure 4.15 Daily Average Wind Speeds at Meteorological Station, 1985-1986

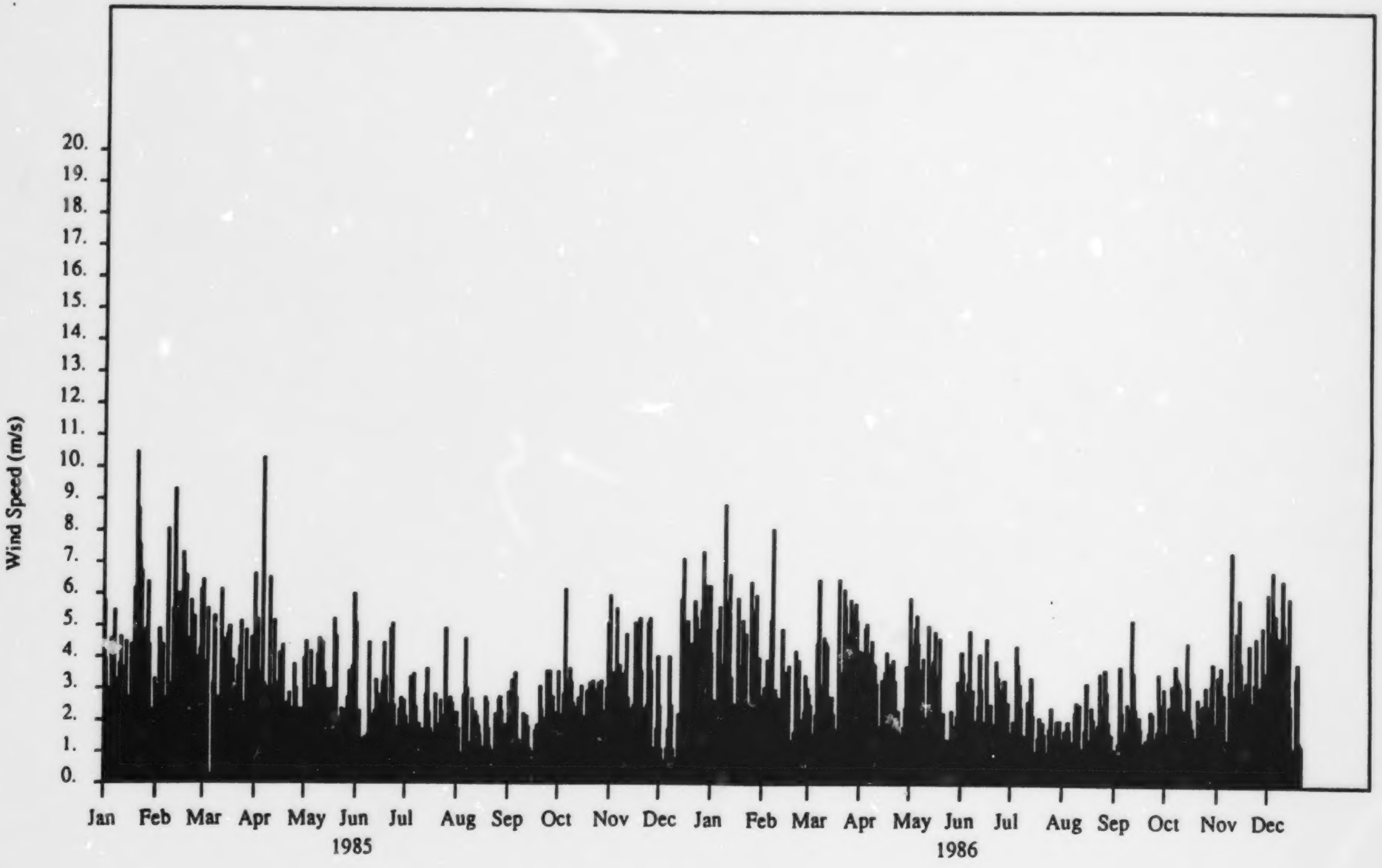


Figure 4.15 Daily Average Wind Speeds at Meteorological Station, 1985-1986

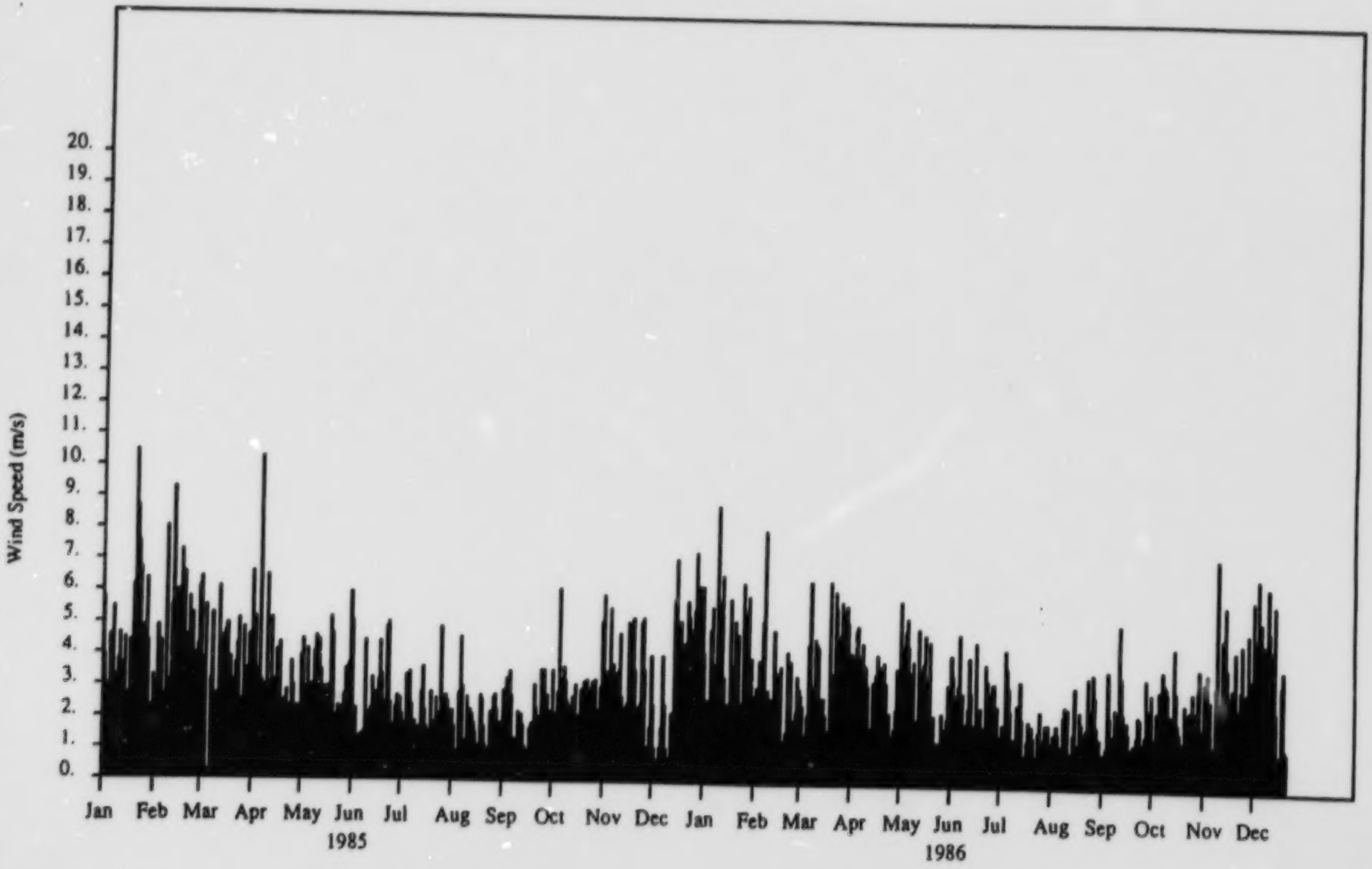
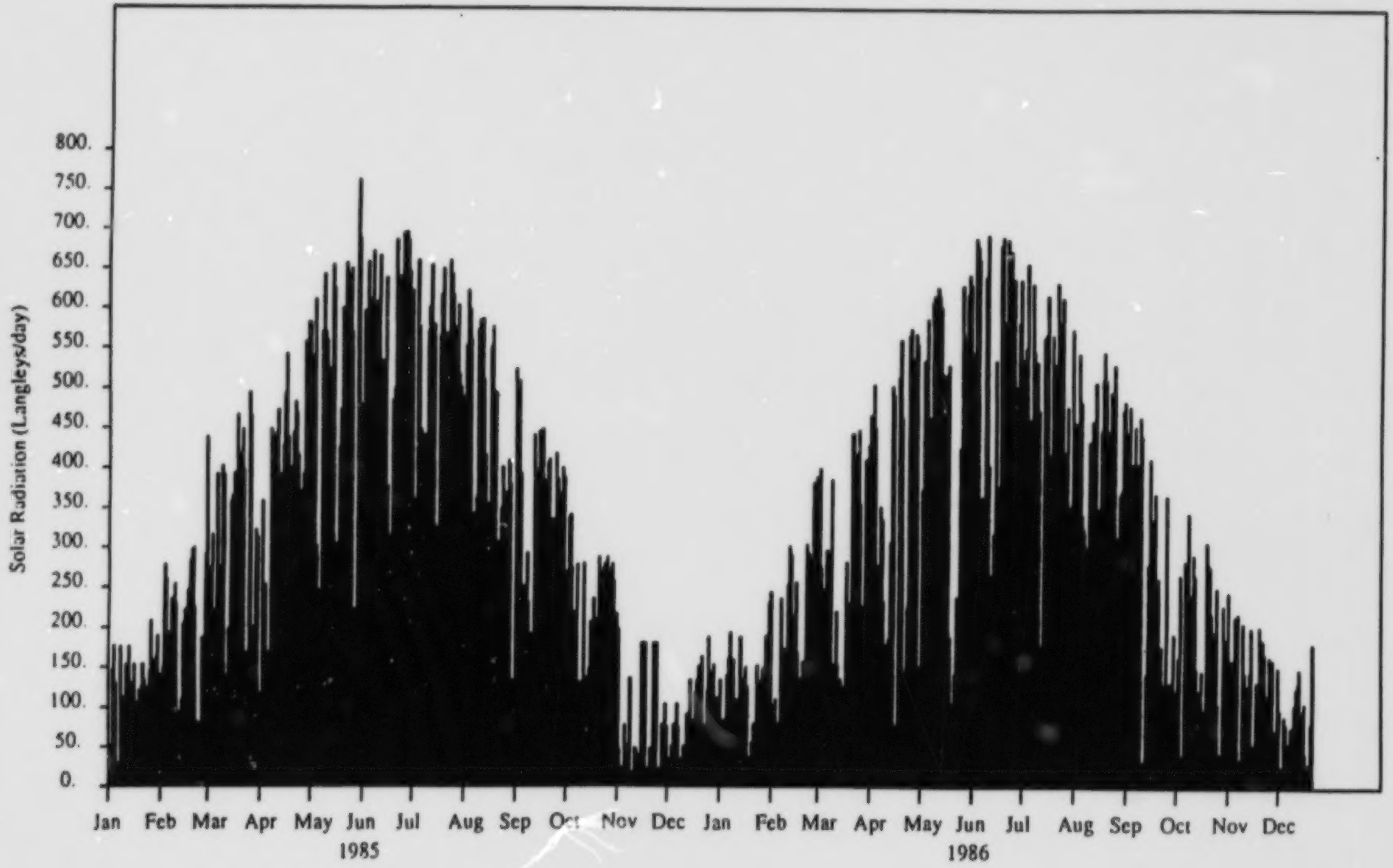


Figure 4.17 Daily Total Solar Radiation at Meteorological Station, 1985-1986



Photograph #5 is an example of the aerial photographs showing corn and grain fields as well as residential areas, forest and roads. Since atrazine is used almost exclusively on corn fields and is used on almost all corn fields, this process provided a good estimate of the total atrazine treated area. The land use distribution observed in 1985 and 1986 is described in the next section regarding watershed discretization.

4.6 Soils and Sediment

4.6.1 Soils

Soil characteristics are a major factor in determining potential soil erodibility, drainage and runoff potential, and chemical affinity. A comprehensive description of the soils in the Nissouri Creek Watershed is necessary, not only for establishing model parameters related to erosion and chemical movement, but also for transferring the knowledge and modelling experience gained here to other areas.

Physical soil characteristics of interest in this study and reasons for their importance follow:

- particle sizes - for the determination of soils potential erodibility and permeability.
- particle and bulk density - for estimating mass of soil, attached chemicals in the soil column, and transport and settling rates.
- infiltration rate - for partitioning surface and sub-surface runoff rates.
- temperature - for adjusting biochemical transformation rates.
- soil moisture - as a general indicator of degree of soil saturation.

Common chemical soil characteristics which are of interest here include:

- phosphorus content - for estimating the mass of phosphorus in the soil matrix.
- atrazine content - for estimating initial soil pesticide mass.
- adsorption/desorption - for estimating adsorption isotherm parameters for phosphorus and atrazine.

- organic content - for determining erodibility and as a general indicator of adsorptive capacity and density.

As part of the detailed sub-watershed studies conducted by PLUARG, soil surveys were conducted (PLUARG, 1979). In these, a detailed surficial soil map was produced (see Figure 3.4). These soil series designations describe the soil in terms of general particle sizes, stoniness and slopes. Detailed investigations were conducted at five bench mark sites within the watershed to describe the complete soil profile in various physical and chemical terms.

Table 4.10 lists related parameters of interest to this study extracted from PLUARG documents. In fact, this information provides all of the basic details required for modelling soil erosion for most of the soils in the watershed.

BEAK conducted cursory soil surveys to verify and complement the PLUARG data. Grab samples of soil were taken on two occasions (May 16, 1986 and November 18, 1986) at the sites indicated on Figure 3.3. Samples were composited from several individual grabs at each site, from the surface and from depths of 15 to 30 cm. These soils were subjected to particle size and phosphorus analysis by MOE in the Rexdale laboratory. Table 4.11 lists soil characteristics and the associated soil series for these samples. Where more than one analysis was available an average value is reported. Using these values and estimating organic content from PLUARG information, the USLE "K" values were estimated and are also presented in this table (Wischmeier and Smith, 1965).

Table 4.12 summarizes surface and subsurface soil atrazine and desethylatrazine concentration reported for soils taken on two occasions. Note the relatively high desethylatrazine concentrations in the May samples. This is due to the fact that a significant amount of the atrazine which was applied in the previous year has decayed to the metabolite. More intensive soil atrazine sampling was conducted by MOE in 1985 and 1986 as part of field level studies. These are reported in Appendix A.

The parameters and chemical concentrations listed in Tables 4.10 to 4.12 were used to estimate model parameters, initial conditions and soil mass constituents used in modelling.

TABLE 4.10

NISSOURI WATERSHED SOIL CHARACTERISTICS (PLUARG, 1979)

Soil Series	Particle Size Class	% of Watershed Area	Infiltration[1] Rate (cm/h)	Drainage	Surface/ Slope	Erosion	Perviousness	Horizon Depths (cm) (A/B/C)
043	course loam	24	1.38[1]	good	level/2-4%	slight-moderate	moderate	33/77/25+
045	fine loam	33	.628[1]/.521[2]	imperfect	level/1%	slight	moderate	24/49/54+
046	fine loam	23	1.13[1]	poor	level/1%	none	moderate	50/90/90+
053	fine loam	6		good	undulating/3%	slight	moderate	30/60/65
055	fine loam	2						
056	fine loam	2						
067	humic clayey	1						
077	humic clayey	2						
SC	stream course complex	8						

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[1] Steady state infiltration, falling head

[2] Steady state infiltration, constant head

TABLE 4.10 (cont'd) NISSOURI WATERSHED SOIL CHARACTERISTICS (PLUARG, 1979)

Soil Series	Particle Density gm/cm^3	Bulk Density gm/cm^3	$NaHCO_3$ ext. P. mg/l	Particle Size Dist'n[3] (% size in min)				Surface Layer Organic Content (%)
				Very fine Sand	Sand	Silt	Clay	
043	2.60	1.87	26	11	28	54	18	3.2
045	2.51	1.65		12	27	58	15	3.9
046	2.64	1.68	17	12	28	50	22	5.0
053								
055								
056			15					
067								
077								
SC								

[1] Steady State Infiltration, Falling Head
[2] Steady State Infiltration, Constant Head
[3] A-Horizon Only

TABLE 4.11 SOIL SAMPLE CHARACTERISTICS, PRESENT STUDY

Soil Series	Depth of Sample	Particle Size Distribution (% size in mm) Very Fine Sand .05-.1	Sand .05-2	Silt .002-.05	Clay .002	Phosphorus (ug/g)	USLE[1] K Factor
$056^7 + 055^3$	surface	15	26	68	7	.66	.59
$056^7 + 055^3$	15 cm	-	41	53	6	.44	N/A
$046^7 + 045^3$	surface	14	24	67	9	.94	.43
$046^7 + 045^3$	15 cm	-	26	68	6	.28	N/A
046	surface	16	20	64	6	1.18	.36
046	20 cm	-	22	72	6	.90	N/A
045	surface	14	26	68	6	.84	.48
$043^7 + 045^3$	surface	15	22	72	5	.76	.53
$043^7 + 045^3$	30 cm	-	65	32	3	.49	N/A
$046^7 + 045^3$	surface	14	19	73	8	.99	.52

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[1] all surface samples were assumed to have a textural and permeability class of 3.

N/A not applicable
- not available

TABLE 4.12 SOIL SAMPLE ATRAZINE AND DESETHYLATRAZINE CONCENTRATIONS

Sample Date	Sample Location (see Figure 3.3)	Depth (cm)	Atrazine (ug/gm)	Desethylatrazine (ug/gm)
08/13/85	1	surface	0.12	0.07
08/13/85	2	surface	0.13	0.03
08/13/85	3	surface	0.08	0.04
05/16/86	1	surface	0.05	0.08
05/16/86	2	surface	0.18	0.13
05/16/86	2	30	0.02	ND
05/16/86	3	surface	0.10	0.11
05/16/86	4	surface	0.12	0.15
05/16/86	4	20	0.04	0.08
05/16/86	5	surface	0.32	0.33
05/16/86	5	15	0.06	0.11
05/16/86	6	surface	0.05	0.10
05/16/86	6	15	0.03	0.04

ND - not detected

Soil temperature and moisture were monitored throughout the study at five sites indicated in Figure 4.18. These were determined using gypsum blocks buried to depths of 0.3 and 1.0 meters. The individual temperature and moisture observations for the sites are listed in Appendix F along with a description of the soil moisture block readings and conversion graphs. This information was used as a general guide to soil temperature modelling and for evaluating the accuracy of soil water trends predicted by HSPF.

4.6.2 Sediment

Stream bed sediment was grab sampled on June 7, 1985 and May 28, 1986 at the sites indicated on Figure 4.19. These samples were analysed for atrazine and desethylatrazine content in order to assess the relative importance of stream sediment as a temporary sink/source for atrazine. Sampling times correspond with periods of most active atrazine application.

Table 4.13 lists the results of these analyses. Note that only station SS9, which lies in the headwaters of the watershed downstream of a large tile drained corn field, displayed significant atrazine levels in both years. Most samples displayed levels near or below the detection limit. At a concentration of 0.018 ug/g (the highest observed) one cubic meter of dry stream sediment would hold about 0.030 grams of atrazine (assuming a bulk dry density of 1.6 gm/cm^3). These results indicate that the sediments are probably not a major sink of atrazine although shortly after applications stream sediment may temporarily hold small amounts of atrazine.

Additional investigations into the movement of atrazine in the stream system were undertaken. On three occasions large volumes of river water were sampled at station N1. These were delivered to the OMAF pesticide laboratory where they were centrifuged to separate the particulate material. Both the aqueous phase and the solid phase material was analysed for atrazine. Table 4.14 lists the results of these analyses. Except for the first sample taken, no atrazine was detected on the particulate fraction while significant amounts were present in the aqueous phase. The first sample was taken during an extreme runoff event during which significant soil erosion occurred. This event closely followed the period of most intense atrazine application and therefore was a likely time to observe soil attached atrazine washoff. These results indicate that the movement of atrazine associated with the solid phase in the stream is minor by comparison to the movement in the aqueous phase.

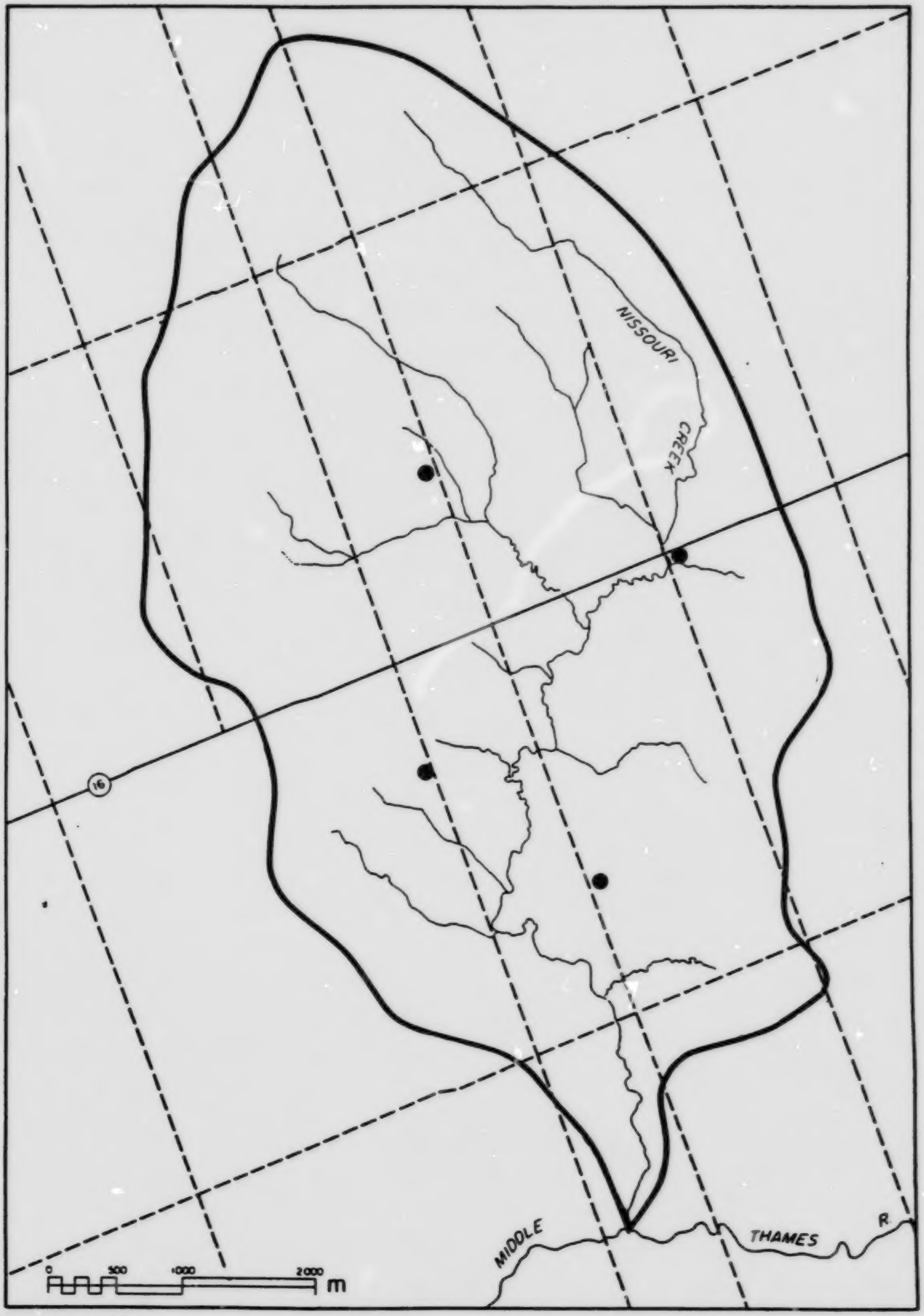

NISSOURI
CREEK
16
MIDDLE
THAMES
R.
0
500
1000
2000
m

FIGURE 4.18

Soil Moisture Measurement Sites

LEGEND
TOWNSHIP ROADS
16 COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
SOIL MOISTURE BLOCKS

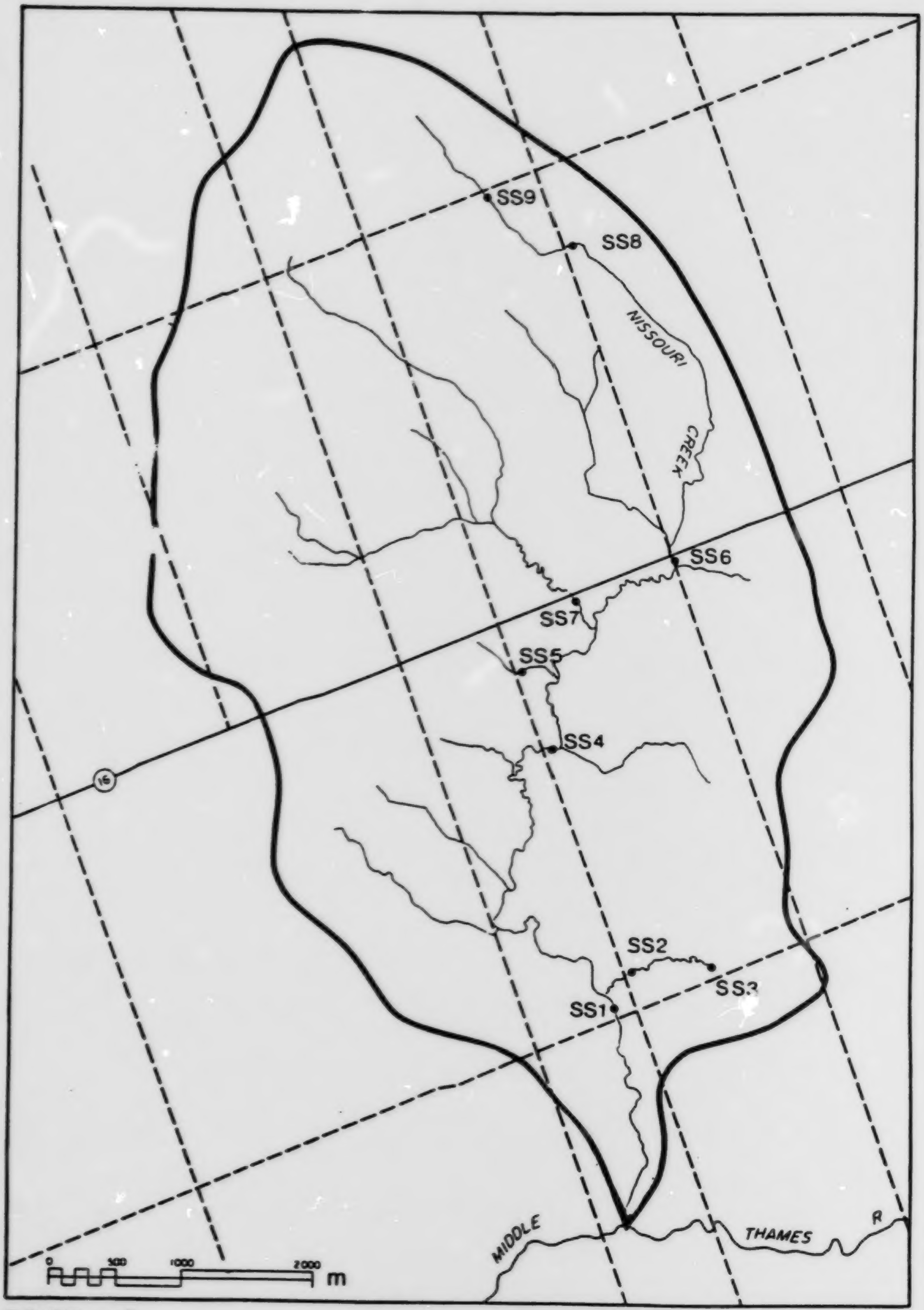

SS9
SS8
NISSOURI
CREEK
SS6
SS7
SS5
SS4
16
SS2
SS3
SS1
MIDDLE
THAMES
R
0
500
1000
2000
m
LEGEND
TOWNSHIP ROADS
COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
SEDIMENT SAMPLING SITES

FIGURE 4.19

Stream Sediment Sampling Sites

TABLE 4.13 STREAM SEDIMENT ATRAZINE CONTENT

Stream Sediment Station (see Figure 4.19)	Atrazine/desethylatrazine Concentration (ug/g)	
Sample Date	07/06/85	28/05/86
SS1	.003/.003	ND/.03
SS2	.003/.014	TR/.03
SS3	.004/.002	ND/.33
SS4	ND/ND	ND/.05
SS5	.018/ND	ND/ND
SS6	.002/.003	TR/.02
SS7	.002/.004	TR/.02
SS8	ND/.004	ND/.05
SS9	.012/.038	.04/.64

TR - trace amounts detected
ND - not detected

TABLE 4.14 AQUEOUS AND SOLID PHASE ATRAZINE CONCENTRATION

Sample Date		Particulate Atrazine Conc. (ug/g)	Aqueous Phase Atrazine Conc: (ug/l)
1985	June 18	0.13	33.0
	July 9	ND	1.2
1986	May 28	ND	4.1

Observed total flow for the event of June 16-19, 1985 at N1 was about 200,000m^3. If it is assumed that the observed aqueous concentration of 33 ug/L is representative of the whole event, then the estimated liquid phase atrazine loss is about 6.6 kg. The observed soil loss for the same period is about 100 tonnes. If it is assumed that the observed solid phase atrazine concentration of 0.13 ug/g is representative of the whole event then the estimated atrazine loss associated with solids is about 13 grams or 0.2% of the total export.

4.6.3 Adsorption/Desorption

A laboratory test was conducted in August 1985 to determine the potential adsorptive capacity of Nissouri Creek Watershed soils for atrazine. In these tests, soil samples from the three major soil types were added to an atrazine solution of known concentration. All solutions were prepared in duplicate. One set of samples was shaken for twelve hours at 4°C. The second set was shaken for twelve hours at 22°C. The samples were then double filtered through glass fibre and the filtrate was submitted to OMAF for atrazine analyses along with the original stock atrazine solution. The atrazine adsorbed by the soil was calculated by difference from the results of filtrate analysis. The final adsorbed atrazine concentrations of the soil are reported in Table 4.15. These values are the average of duplicate test samples. These results were used as a first estimate to select Freundlich adsorption isotherm parameters for modelling and represent the upper limits of soil atrazine concentration.

4.7 Atrazine Use

The Hazardous Contaminants Coordination Branch of MOE conducted information surveys of Nissouri Creek Watershed farmers in 1985 and 1986. The methods and results of these surveys are presented in Appendix B. The purpose of these surveys was to determine the amount and areal extent of application of atrazine. In 1986 additional information regarding the time of application was solicited. Application rates were estimated for corn fields for which no survey information was available. The response rate to surveys was more than 80% in each year.

Table 4.16 summarizes some of the results of these surveys. The key observations are that atrazine application rates vary considerably from one operator to another ranging

TABLE 4.15 ADSORPTION POTENTIAL FOR ATRAZINE ONTO NISSOURI WATERSHED SOILS

Soil Series	Final Adsorbed Atrazine Conc. (ug/g)		Initial Soil Atrazine Conc. (ug/g)
	40°C	22°C	
$046^7 + 045^3$	6.4	9.9	.12
$045^7 + 046^3$ (moderate slope)	5.5	5.3	.13
$045^7 + 046^3$ (flat)	7.2	9.4	.08

Original solution atrazine concentration was 3180 ug/l

TABLE 4.16

SUMMARY OF ATRAZINE USE INFORMATION 1985-86

	1985		1986			
Application Period	Reported Area of Appl'n (ha)	Appl'n Rate (kg/ha)	Reported Area of Appl'n (ha)	% of Reported Area	Appl'n Rate (kg/ha)	% of Reported Mass
April	NA	NA	7	0.7	4.93	1.9
May 1-15	NA	NA	320.5	32	1.52	26.4
May 16-31	NA	NA	481	48	1.93	50.4
June	NA	NA	133.5	13.3	2.33	16.9
July	NA	NA	28	2.8	0.70	1.1
October	NA	NA	32	3.2	2.00	3.5
Totals	1,186		1,002	100.0		100.0
Averages		1.85			1.84	

# of reported cooperators using atrazine:	1985 - 42 1986 - 39
Total Reported Mass of atrazine applied (kg):	1985 - 2,195 1986 - 1,845
Total area of corn (ha):	1985 - 1,545 1986 - 1,112
Total estimated mass of atrazine applied (kg):	1985 - 2,859 1986 - 2,046

NA - not available

from 0.7 kg/ha to 5.8 kg/ha. The time of application ranges from late April (pre-planting application) through May and June (pre and post emergent applications) to October (after crop removal). Although the application rates vary and the areas affected vary considerably from one year to the next the average application rate was consistent at about 1.85 kg/ha. One manufacturer recommends application rates ranging from 2.0 to 3.75 kg/ha depending upon the soil type. Recommended application rates for the silty loams of this watershed are about 2.5 kg/ha.

The data in Table 4.16 was used in pesticide modelling to estimate the timing and rate of atrazine application.

5.0 MODELLING

5.1 General

The HSPF Application Guide recommends a logical series of steps to model application. In this chapter the approach to each step is discussed along with modelling results from this study. Application steps include the following:

- Study definition is the identification of the questions and the level of detail to which HSPF will be applied; an assessment of the availability of data and its usefulness; and a review of resources available for data collection, analysis and modelling to the desired detail.

- Development of a modelling strategy involves the segmentation and discretization of the watershed, and linkage of land and channel elements so that all important characteristics and features are appropriately represented.

- Learning the operational aspects of HSPF is an essential step to developing input sequences, performing necessary linkages, simulating information and producing the most meaningful output.

- The handling of time series data in HSPF is a major aspect of modelling due to the enormous volume of information both input and that produced in simulation. Successful application of HSPF necessitates familiarization with storage, retrieval and management of time series data.

- Parameter development focuses on the familiarization and selection of process-oriented parameters for land and stream modules.

- Calibration is the process by which model parameters, especially those which cannot be deterministically evaluated, are adjusted until simulated results closely reflect observed data. Verification is a complementary process in which the model is applied to an independent data set as a test of the validity of process parameters. Calibration/verification is often a feedback process.

- *Application to alternate scenarios* is often the main objective of a modelling exercise and involves the adjustment of model input, linkages, and parameters to reflect various proposed alternative operational schemes, and the interpretation of simulated results.

This report does not document HSPF or provide detailed descriptions of its structure and modules since this is adequately accomplished in the 767 page Users Manual (Johanson *et al.*, 1984) and the 177 page Application Guide (Donigian *et al.*, 1984). These are excellent support documents that deal with all aspects of the model and its application in an easy reference format with examples. The discussion included here is limited to the experiences of the study team and the procedures followed. It should be recognized that HSPF has simulation capabilities beyond those used in this study. The reader is referred to the User's Guide for a full description of these.

5.2 Study Definition

The following questions apply in this study:

- Can HSPF simulate erosion and sediment transport for a variety of land use and land characteristics in a small agricultural watershed?
- Can HSPF simulate atrazine behaviour and loss?
- Can a variety of land management scenarios be evaluated through HSPF?
- Is HSPF a practical tool for use in the land management process in Ontario?

To answer these questions a set of aerial and temporal scales were selected. The watershed computation units are as small as a few hectares (field size) while stream channels have contributing areas and lengths ranging from 170 hectares and a few hundred metres to over a thousand hectares and five kilometres. Temporal scale is based upon a one hour time step which was felt to be a practical compromise, bearing in mind computation time, input data variability, and internal process kinetics.

Supporting data were available from PLUARG for specific information such as soil characteristics and general information such as unit area loading data. Some other data were available on area maps (topography, drainage, etc.) and in OMAF records. Available information was valuable and reliable; however the bulk of the data, time varying and site specific, had to be measured or verified in this study. Land management practices have changed since PLUARG and time series data (streamflow, meteorology, etc.) is fully dynamic in all respects. Most meteorological data cannot be transferred from weather stations in excess of 20 kilometres away without a sacrifice to accuracy, especially in terms of precipitation.

The resources available to this investigation allowed for an intensive, event oriented monitoring program for a 30 month field period. This period is adequate in that it provides for two calendar years and a period to 'debug' the monitoring system. Two calendar years allow for a calibration on one year and verification using the other year of data. The scope of work did not allow for a detailed survey of individual farm plans and practices but rather a generalized survey of pesticide use. Field studies were conducted by MOE to measure net decay rates of atrazine in study plots on two successive years to enhance model calibration for atrazine decay.

Computer requirements for HSPF applications are substantial as simulations can be very computation intensive. BEAK used a SUN 3/75 micro system. To our knowledge this was the first time that HSPF had been applied to this level of detail without using a main frame computer. Computer runs with a one hour time step required from 20 minutes to 2 hours to complete depending upon the simulation period and parameters involved.

The model demonstration phase was not intended to be a detailed quantitative review of land management practices but rather a demonstration of the approach to analysis and a demonstration of the sensitivity of HSPF to changes in land management practices. In effect, this project was a "first cut" at analysing BMP's in Ontario using HSPF. Some generalized results are presented in the next chapter which address the merits of certain BMP's.

5.3 Discretization

Discretization is the process by which the study land area and watercourse are segmented into units termed pervious land segments (PLS's) and reaches respectively. These units have homogeneous attributes throughout. In general, the aspects of a watershed which should be considered in a simulation exercise aimed at predicting runoff, soil, phosphorus and atrazine losses as is the case in this study include the following:

- climate,
- soils,
- land use,
- topography, and
- hydraulic characteristics of the channels.

Climate does not vary significantly over the Nissouri Creek Watershed, with the exception of individual precipitation events, therefore, no segmentation for climatic zones was made. Climatic segregation is only necessary in large river basins. As discussed in the previous chapter, several rain gauges were deployed in this study to aid in accounting for the spatial variability of this parameter. However, variability in precipitation is random in nature and spatial trends do not exist. Three separate precipitation time series were input to the model and the effects of these records were distributed amongst the land areas. Microclimatic variation in other meteorological parameters was considered to be insignificant within the temporal and spatial scales used in the assessment.

The watershed was initially segmented on the basis of soil types. Four different soil types are encountered in sufficient proportion for consideration. An overlay of the watershed was placed over the PLUARG soils map (see Figure 3.4) and the four soil types were delineated. Small areas of other soil types were grouped with the adjacent soil type which was closest in terms of properties.

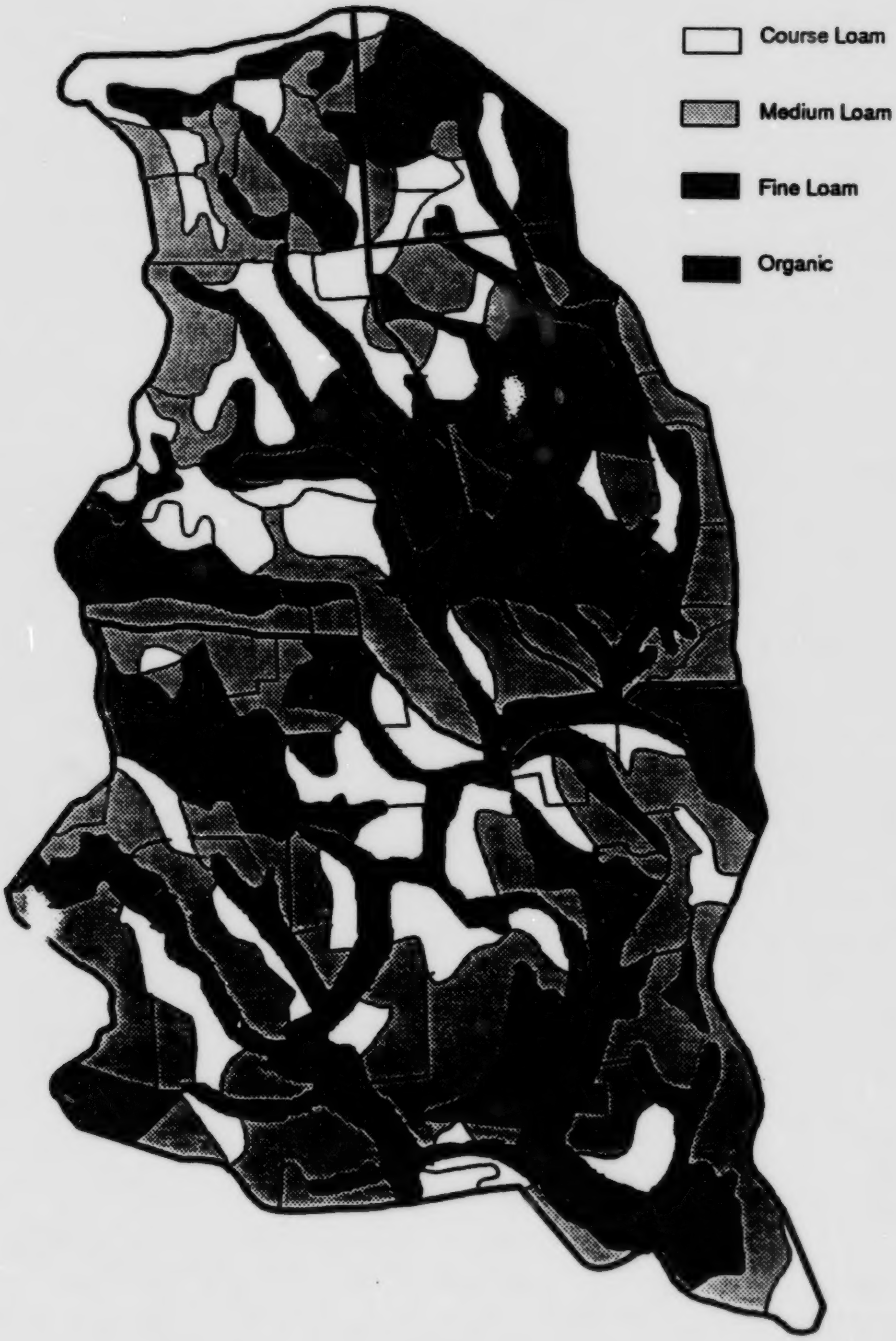
Table 5.1 identifies the four soil types and some relevant features of each. Figure 5.1 is a map with the final homogeneous land area boundaries overlain. The four soil types are highlighted for illustration of their relative distributions. It should be noted that the

TABLE 5.1 CHARACTERISTICS OF FOUR SOIL TYPES USED IN DISCRETIZATION

Soil Unit [1]	Texture	Taxonomic Classification	Topographic Class	Drainage	Area of Watershed (ha)	% of Watershed
043 + 053	silty loam	Orthic Gray Brown Luvisol	0.5 to 5% regular 5 to 9% irregular	well drained	619	20
045 + 055	silty loam	Gleyed Orthic Gray Brown Luvisol	0.5 to 5% regular	imperfect	1,148	37
046 + 056	silty loam	Orthic Humic Gleysol	0 to 2% regular	poor	957	31
067 + 077 + SC	organic-variable	Humisol	0-0.5% variable	very poor-variable	368	12

[1] System of Soil Classification for Canada designation.

FIGURE 5.1
Discretized Watershed
with Soil Types


Course Loam
Medium Loam
Fine Loam
Organic

first three soil types on Table 5.1 are not substantially different in texture. The major difference lies in their topographic class and drainage. The first soil type generally lies on high ground or on slopes which are well drained. Some of the finer particles have been washed out of this soil further enhancing its drainage potential. The second and third soil types lie progressively nearer to the bottom land and at the base of slopes where finer material has been deposited. These soils are therefore less permeable and lie closer to the groundwater table. Tile drainage is extensive in these soils but this does not effect the soils characteristics. The last group of soils is a "catch all" for generally non agricultural soils (although cultivation does take place on about 30% of these soils). The stream course complex soil (SC) has variable characteristics and was grouped with types 067 and 077 for convenience and because agricultural use of these areas is low.

The next phase of discretization addressed was topography (slopes). Topographic maps were delineated by four slope classes; 0 to 0.5%, 0.5 to 2%, 2 to 5% and greater than 5%. The soil type map was overlain onto the slopes map and further segmentation of areas was made. Table 5.2 summarizes the relative proportion of various slopes. Figure 5.2 is a discretized version of the topographic watershed map in terms of the four slope classes. Since soil types are found to roughly correlate with slopes in this system relatively few additional area boundaries are required when slopes are added to the discretization system.

Finally, land use was incorporated into the discretization system. Land use was taken to mean crop type and three types were adopted; corn, mixed grains and other crops, and non-cultivated and non-agricultural. Since this study addresses atrazine migration and atrazine is applied exclusively to corn fields this particular land use was felt to warrant a separate classification. All other cultivated fields are lumped, although it is recognized that row crops such as soybeans differ in their pollutant transfer potential than do non-row crops such as wheat. This system is a compromise between descriptiveness and computational efficiency. Likewise, non-cultivated fields in agricultural use (ie. pasture) have been lumped with non-agricultural areas (ie. roads) as a compromise. It was felt that the subtle differences in pollutant transfer between these land uses would not justify further delineation. It has been assumed that all corn fields are subjected to conventional tillage practices. This was the observation of field crews. This system involves moldboard plowing in the spring with a distribution of pre-seed, pre-emergent, post-emergent and post-harvest pesticide application and winter spreading of manure.

TABLE 5.2 SLOPE CLASS DISTRIBUTION

Slope Class	Area (ha)	% of Watershed
less than 0.5%	127	4
0.5 - 2.0%	1,494	48
2.0 - 5.0%	1,172	38
greater than 5%	317	10

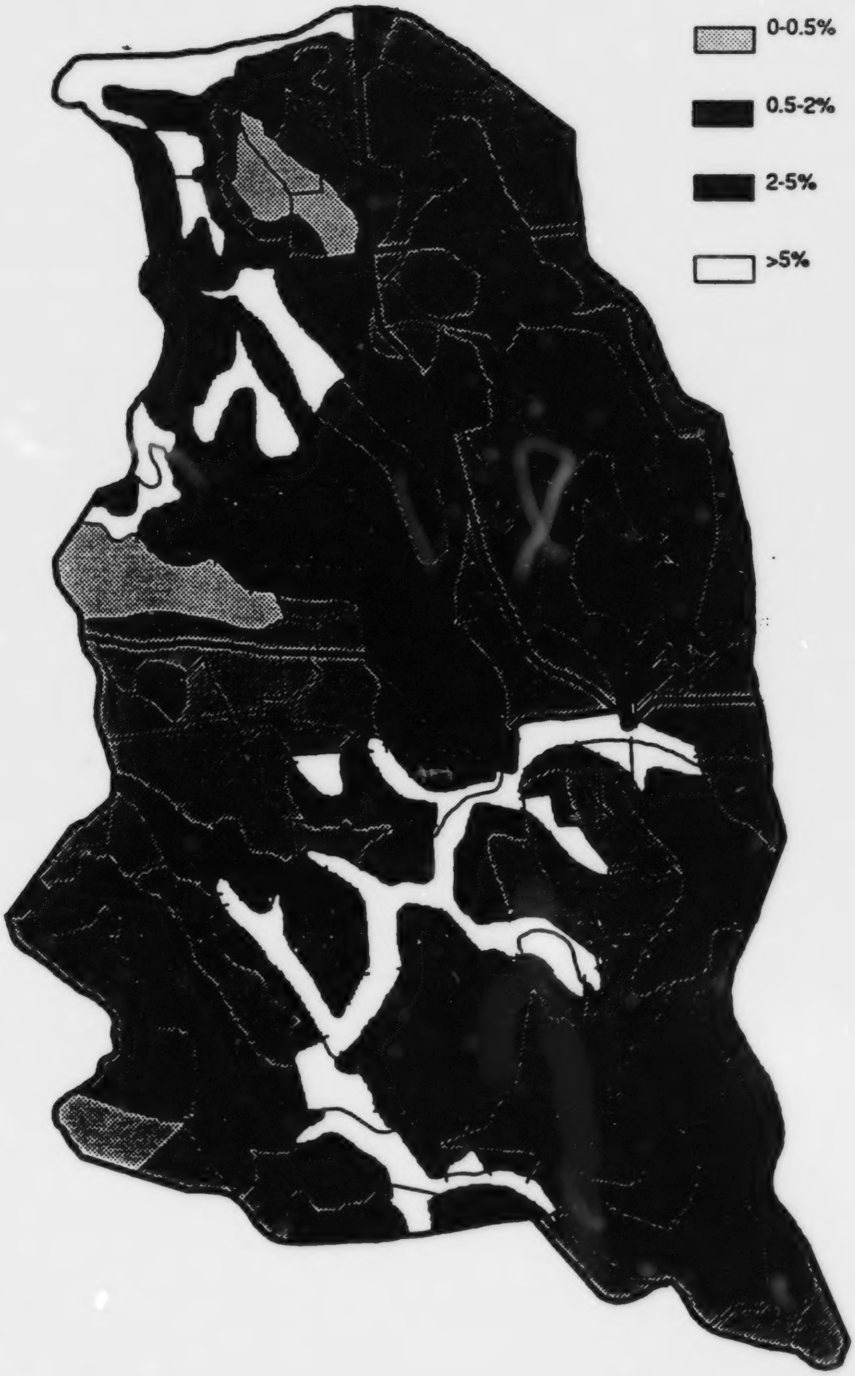


FIGURE 5.2
Discretized Watershed
with Slope Classes

Variations on these practices are limited and are therefore not likely to alter overall simulation results.

In this system, land uses change from year to year as crops are rotated. Table 5.3 summarizes the relative distribution of each land use type in 1985 and 1986. Figures 5.3 and 5.4 show the discretizied form of the land use in these years. The imposition of land use onto slopes and soil types introduces an angularity to the overall discretization pattern since land use tends to follow rectangular field lines. If a larger scale is addressed, and detailed field level information is not available, then a land use system based on crop rotation such as is used by OMAF can be employed. The system used here takes advantage of the detailed field-crop information which was available.

HSPF is a lumped parameter model. That is, all areas with similar characteristics of soil type, slope and land use can be lumped as one area for computation. Areas need not be contiguous to be lumped together. This system therefore results in up to 48 homogeneous land areas, (i.e., 4 soils x 4 slopes x 3 land areas = 48). To reduce computational complexity further, very small areas (less than 7 hectares) were grouped with the closest slope class. Land use and soil type classification boundaries were not crossed. This process decreased the 1985 land area number from 31 to 28 and the 1986 number from 33 to 22 with a proportional decrease in simulation run time. Several land classifications had no significant area associated. Table 5.4 lists the PLS's for the 1985 and 1986 simulation periods along with their soil type, slope and land use.

The watershed drainage system was discretized so that output information sites (i.e., the end of each reach) corresponded to the monitoring sites allowing direct comparisons between observed and predicted loadings. Figure 5.5 illustrates the four sub-drainage areas or reach contributing areas and the channels within each area. Table 5.5 lists relevant reach information. This system allows for examination of three areal scales (less than 200 hectares, 500-800 hectares, and 3000 hectares). The reach contributing area map was overlain on the fully discretized watershed and further divisions were made so that no areas were split between sub-basins. Each Pervious Land Segment is then fractioned to account for the portion of that area which flows to each of the four reach contributing areas.

TABLE 5.3 LAND USE AREA SUMMARY

Land Use Designation		Area (Ha)	% of Watershed
Corn	1985	1,545	50
	1986	1,112	36
Mixed-cultivated	1985	1,113	36
	1986	1,490	48
Non-cultivated	1985	434	14
	1986	490	16

FIGURE 5.3
Discretized Watershed
with Land Use, 1985

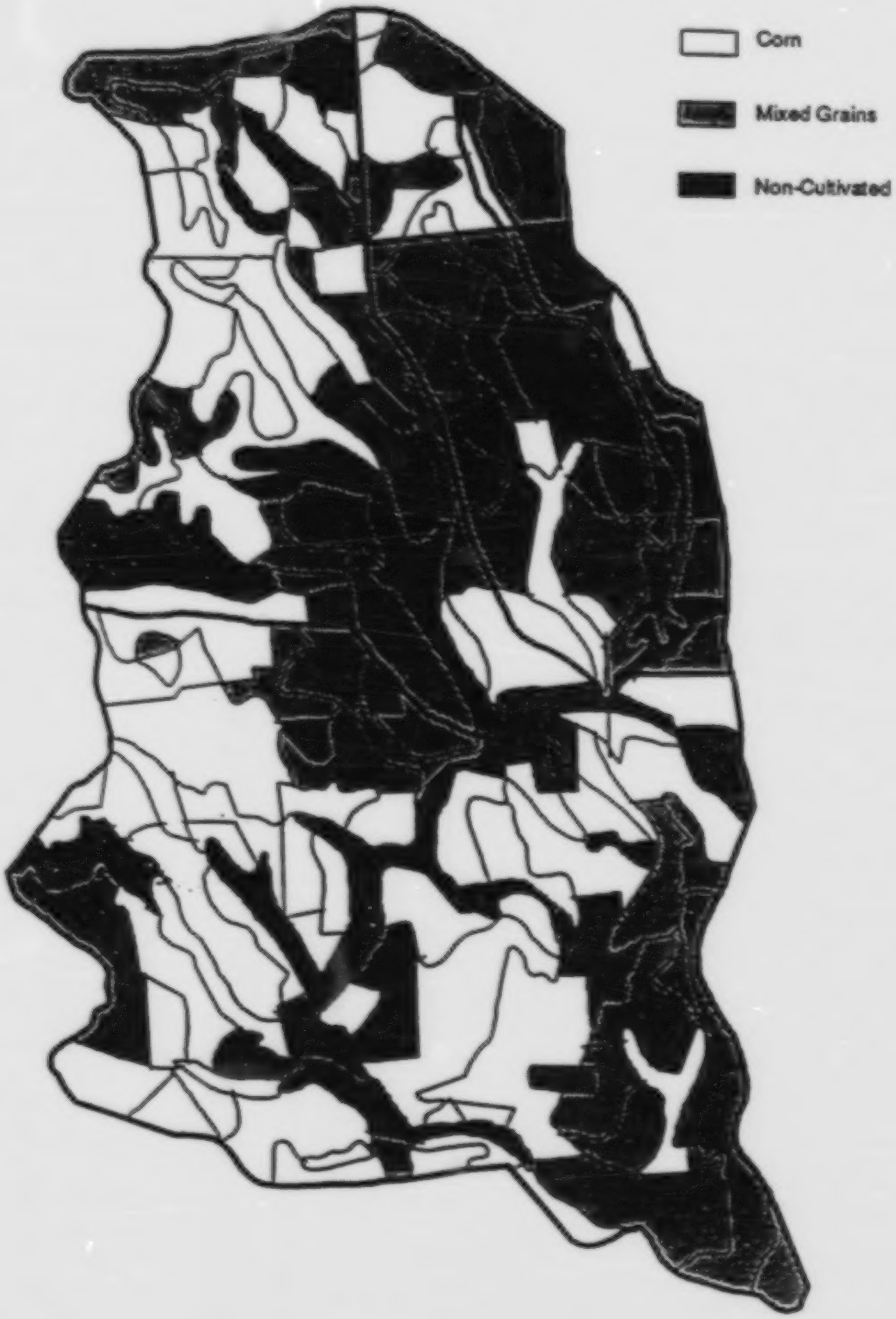

Corn
Mixed Grains
Non-Cultivated

FIGURE 5.4
Discretized Watershed
with Land Use, 1986

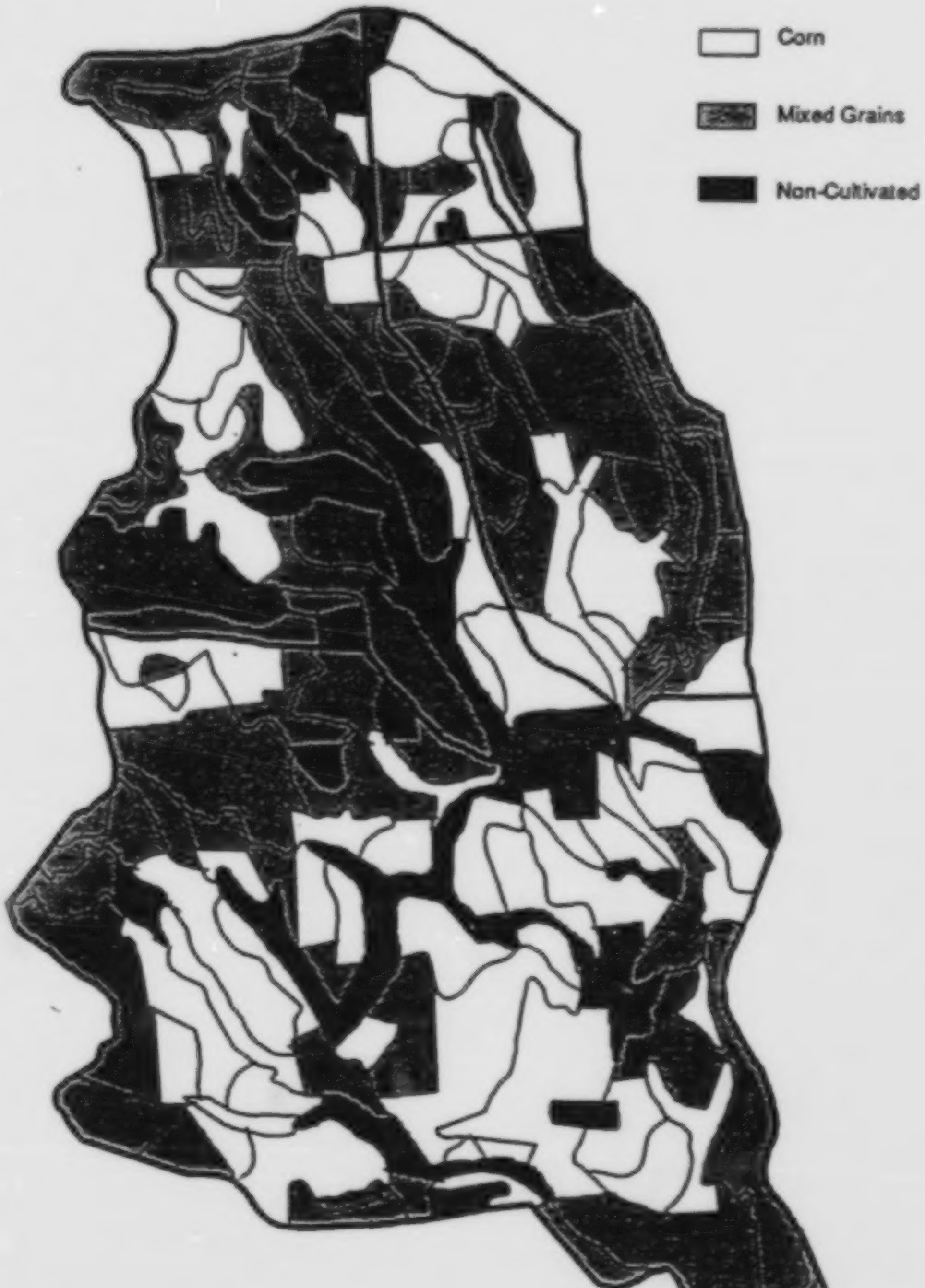

Corn
Mixed Grains
Non-Cultivated

TABLE 5.4 HSPF PERVIOUS LAND SEGMENT CHARACTERISTICS

PLS #		Soil Type	Average PLS Slope (%)	Land Use
1985	1986			
122	122	sand/silt loam	1.25	mixed grains
131	131	sand/silt loam	3.5	corn
132	132	sand/silt loam	3.5	mixed grains
133	133	sand/silt loam	3.5	non-cultivated
141	141	sand/silt loam	7.0	corn
142	142	sand/silt loam	7.0	mixed grains
211	-	silt loam	0.25	corn
221	221	silt loam	1.25	corn
222	222	silt loam	1.25	mixed grains
223	223	silt loam	1.25	non-cultivated
231	231	silt loam	3.5	corn
232	232	silt loam	3.5	mixed grains
311	-	fine silt loam	0.25	corn
312	312	fine silt loam	0.25	mixed grains
313	-	fine silt loam	0.25	non-cultivated
321	321	fine silt loam	1.25	corn
322	322	fine silt loam	1.25	mixed grains
323	323	fine silt loam	1.25	non-cultivated
331	-	fine silt loam	3.5	corn
332	332	fine silt loam	3.5	mixed grains
333	333	fine silt loam	3.5	non-cultivated
341	-	fine silt loam	7.0	corn
413	413	organic	0.25	non-cultivated
431	431	organic	3.5	corn
432	-	organic	3.5	mixed grains
433	433	organic	3.5	non-cultivated
442	442	organic	7.0	mixed grains
443	443	organic	7.0	non-cultivated

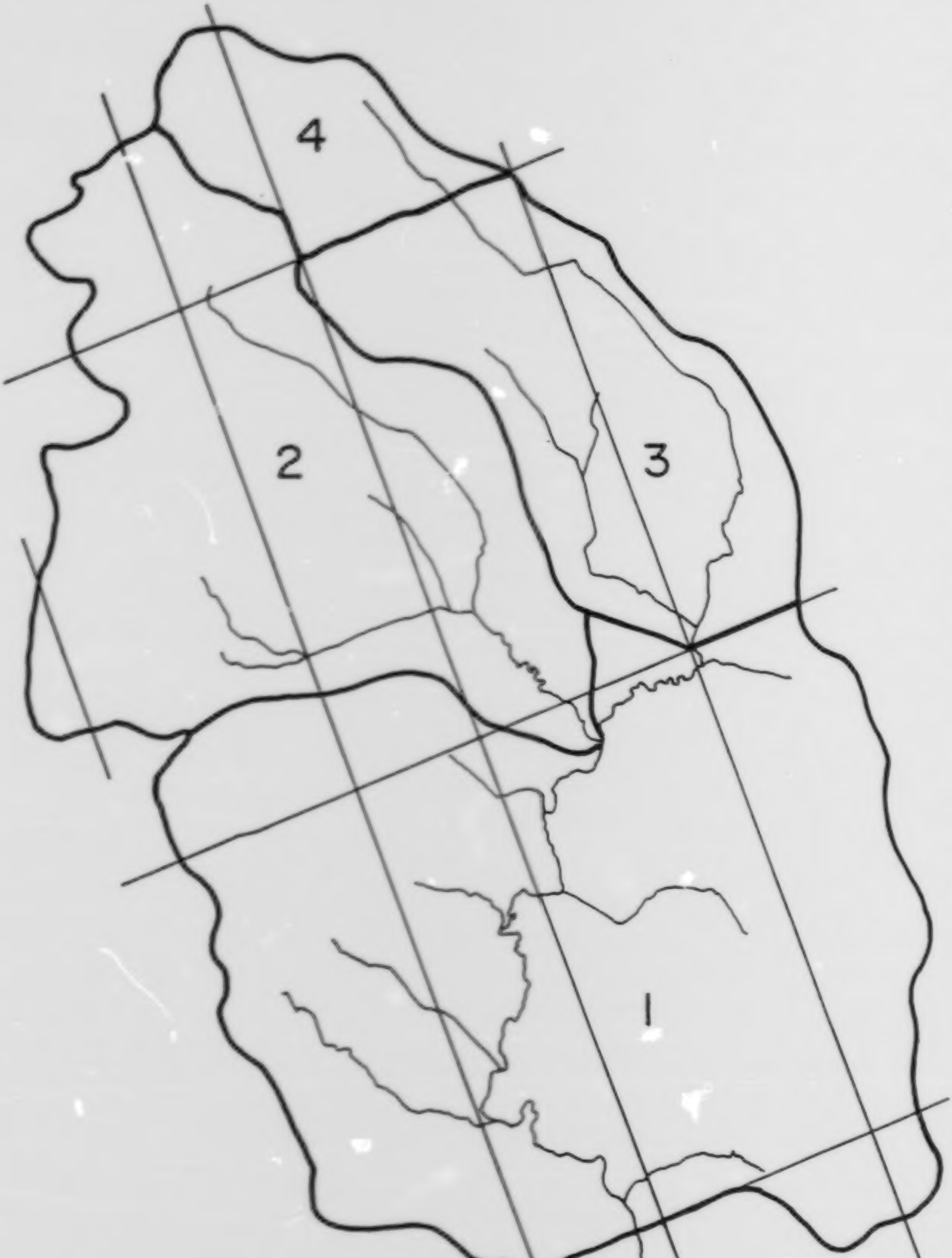


FIGURE 5.5 Reach Designations

TABLE 5.5 REACH CHANNEL AND CONTRIBUTING AREA SUMMARY

Reach	Reach Contributing Area (ha)	Channel Length (m)	Channel Slope (m/m)
N1	1,616	4,850	.0066
N2	832	4,000	.0093
N3	476	5,100	.0039
N4	168	740	.0081

5.4 Time Series Data

5.4.1 Input Time Series

The hydrologic processes modelled by HSPF are "driven" by weather input information. The selection of desired simulation parameters implies a selection of HSPF modules and module groups which must be flagged as "operational". Table 5.6 lists the modelling processes desired, associated HSPF modules and groups, mandatory time series, and time step. Note that the output time series from some modules such as SNOW and SEDMNT are input time series to other modules such as PWATER and SEDTRN. The input time series and internal time series are linked and possibly routed to output time series through the EXTERNAL SOURCES, NETWORK and EXTERNAL TARGETS blocks.

The time series store (TSS) is a large storage allocation which is loaded with input and output time series using model utility programs. During each simulation, information is transferred into and out of the appropriate storage addresses within the TSS.

The input time series used in simulating the Nissouri Creek Watershed included three separate precipitation time series. These records were formed from the three tipping bucket rain gauge records. Each PLS was assigned a particular distribution of rain from one, two or three of the gauge records. For example, if 70% of a particular PLS was in close proximity to gauge #1 and the remainder was near gauge #3, then 0.70 times each hourly precipitation value for gauge #1 and 0.30 times the gauge #3 data would be added and routed to that PLS. In this way spatial and temporal variation in rainfall, quite apparent during thunderstorms, could be more accurately allocated. Wind speed, air temperature, solar radiation, evaporation rate, and dew point temperature were applied equally to all PLS's at the time steps indicated in Table 5.6.

All input time series are included in Appendix E.

5.4.2 Output Time Series

Model output time series can be "tailor made" to suit the application. Space is allocated in the TSS according to anticipated size and other data characteristics (ie. time step, mean or point valued). Then, by selecting various optional forms of output and linkages

TABLE 5.6 HSPF MODULES AND INPUT TIME SERIES

Process to be Simulated	HSPF Module/Group		Required Input Time Series	Time Series Time Step (hr)
snow accumulation and snow melt	PERLND	SNOW	precipitation	1
			dew point temperature	24
			air temperature	1
			wind speed	1
			solar radiation	1
water budget and runoff from pervious land	"	PWATER	same as SNOW	-
			evaporation	24
			SNOW	1
soil erosion and transport to channels	"	SEDMNT	SNOW	1
			PWATER	1
			precipitation	1
pesticide processes and runoff from pervious land	"	PEST	SEDMNT	1
			PSTEMP	1
			MSTLAY	1
phosphorus processes and runoff from pervious land	"	PHOS	SEDMNT	1
			PSTEMP	1
			MSTLAY	1
hydraulic routing of runoff in channels and	"	HYDR	PWATER	1
advection of dissolved material	"	ADCALC	HYDR	1
			CONS	1
soil layer moisture*	"	MSTLAY	PWATER	1
soil temperature*	"	PSTEMP	air temperature	1
sediment transport in channels	RCHRES	SEDTRN	HYDR	1
			SEDMNT	1
pesticide transport in channels	"	CONS1	ADCALC	1
			HYDR	1
			PEST	1
phosphorus transport in channels	"	CONS2	ADCALC	1
			HYDR	1
			PHOS	1

*required for the agri-chemical modules

the simulation data is placed in storage. Each group of processes in HSPF has a catalogue of output that can be accessed. Some of these output data are intermediate state variables useful during calibration while others are final forms of the simulation parameters. As an example, the output catalogue module PERLND group PHOS lists 34 optional output parameters including intermediate state variables such as surface layer adsorbed phosphate and total phosphorus in the soil; intermediate material flux such as percolation rate of soluble phosphorus from the surface soil layer to the upper zone; and final output time series such as total outflow of sediment associated phosphorus or total outflow of phosphorus from the PLS. By selecting the most informative output time series during calibration and during model application, efficient use can be made of the TSS while at the same time model evaluation is facilitated. Final output time series data such as outflows at each monitoring station or hourly pesticide transport in the channels is routed to the pre-assigned storage space in the TSS.

Intermediate and final output time series can be routed to PLTGEN, the plot file creation module, or DISPLY, the summarizing module for convenient output review. The management of enormous data files and easy access to many forms of output time series data are major capabilities of HSPF which facilitate application and eliminate the need for modifications to the I/O code. Utility modules are discussed in Section 6.3.

Examples of input and output time series routing and linkages are presented in the Addendum for a full simulation run as well as for some utility routines. The User's Manual is the best reference for those wishing to prepare an HSPF simulation.

5.5 User Controlled Input

5.5.1 General

The user controlled input (UCI) includes a variety of information types which may be adjusted or altered during calibration and application. The UCI may include the following types of information:

- duration of a run,
- time step,
- run title,

- interpreter output level (level of complexity of system output),
- address of the TSS,
- operations and operation order (HSPF modules invoked),
- special actions to be performed (land management practices),
- print detail flags,
- module groups invoked,
- initial conditions and state parameters,
- process parameters,
- process options (in some cases 2 or more methods are available for computation such as sand load transport and adsorption),
- F-tables (channel hydraulics),
- utility module parameters and output files,
- TSS input file addresses,
- time series linkages, and
- output file TSS addresses.

This section includes discussion of the special actions, initial conditions, state variables and process parameters used to model the Nissouri Creek Watershed. Other information contained in the UCI is of interest to model users only. All copies of UCI are provided in the Addendum to this report.

5.5.2 State Variables and Process Parameters

At the onset of calibration a sensitivity analysis was conducted to identify those parameters and variables which are key to model accuracy. Those parameters and variables which are not likely to strongly affect results were set at measured values if available or were set at values taken from the literature or at values recommended in the User's Manual (default values are available for most parameters and recommended values are offered for others). The ARM user's manual (Donigian et al., 1977) is also a good reference for selecting reasonable starting values for most variables and parameters.

Table 5.7 is a summary listing of the sensitive model variables and parameters, their implications in the simulation of processes and their relative importance to final output. Several of these parameters can be varied throughout a year using monthly

TABLE 5.7 SENSITIVE PARAMETERS AND IMPLICATIONS IN NISSOURI WATERSHED MODEL

Module	Group	Parameter/ Variable	Explanation	Relative Sensitivity and Implications
PERLND	SNOW	COVIND	Maximum snow pack depth (water equivalent) at which the PLS is entirely covered.	Moderate sensitivity. Higher snowmelt rates will occur with lower values. This affects timing of runoff but not total runoff volume.
		CCFACT	Snow condensation/convection melt rate parameter.	Moderate sensitivity. Affects snowmelt rates and timing of runoff but not total runoff volume.
		MWATER	Maximum water content of snowpack.	Moderate sensitivity. Affects melt water runoff timing.
		MGMELT	Rate of snowmelt by ground heat.	Moderate sensitivity. Affects pack accumulation and base flow rates.
		SNOW-INIT	Initial values for pack ice, water and snow.	Medium sensitivity during snowmelt. Affects runoff rates and total volume of runoff.
	PWATER	LZSN	Lower zone nominal water storage capacity.	Very sensitive. Affects runoff rates from surface and subsurface.
		INFILT	Infiltration capacity of soil	Very sensitive. Partitions surface and subsurface runoff volume and timing.
		LSUR	Length of overland flow path	Moderate sensitivity. Affects total surface and subsurface runoff volumes and timing and sediment delivery ratio.

TABLE 5.7 (cont'd) SENSITIVE PARAMETERS AND IMPLICATIONS IN NISSOURI WATERSHED MODEL

Module	Group	Parameter/ Variable	Explanation	Relative Sensitivity and Implications
PERLND	PWATER	SLSUR	Slope of overland surface	Very sensitive. Same as LSUR.
		AGWRC	Groundwater recession rate	Very sensitive. Affects baseflow rates.
		CEPSC	Interception storage capacity	Moderate sensitivity. Affects surface runoffs volume and balance between evaporation and runoff.
		UZSN	Upper zone nominal water storage capacity	Very sensitive. Affects surface and subsurface runoff volumes and timing.
		NSUR	Manning's "n" for overland flow	Moderate sensitivity. Same as LSUR.
		INTFW	Interflow inflow parameter	Moderate sensitivity. Determines proportion of subsurface runoff volumes and timing.
		IRC	Interflow recession rate	Very sensitive. Determines rate of interflow.
		PWAT-STATE	Initial storages	Very sensitive for initial few months, then minimal sensitivity.
	SEDMNT	SMPF	Supporting management practice factors	Very sensitive. Affects erosion rates linearly.
		KRER, JRER	Soil detachment parameters	Moderate sensitivity. Affects mass of soil detached and available for sheet erosion.
		KSER, JSER	Soil washoff parameters	Very sensitive. Determines rate of soil sheet erosion.
		KGER, JGER	Soil matrix scour parameters	Very sensitive. Determines rate of rill and gully erosion.

TABLE 5.7 (cont'd) SENSITIVE PARAMETERS AND IMPLICATIONS IN NISSOURI WATERSHED MODEL

Module	Group	Parameter/ Variable	Explanation	Relative Sensitivity and Implications
PERLND	SEDMNT	AFFIX	Rate of soil re-attachment	Moderate sensitivity. Affect mass of soil available for sheet erosion.
		COVER	Portion of PLS shielded from rainfall impact.	Very sensitive. Affects soil detachment rate.
		SED-STOR	Initial detached soil	Minimum sensitivity. Only affects first erosion event.
	PSTEMP	ASLT, BSLT	Surface soil layer temperature parameters	Moderate sensitivity. Affects biochemical rates of phosphorus and pesticide in soil.
		ULTP	Upper soil layer temperature parameter	Same as above in upper layer.
		LGTP	Lower soil layer temperature parameter	Same as above in lower layer.
	MSTLAY	SLMPF	Percolation rate of solutes from surface to upper layer	Moderate sensitivity. Affects leaching rate of soluble chemicals in soil.
		ULMPF	Percolation rate of solutes from upper to lower layer	Same as above.
		LLMPF	Percolation rate of solutes from lower layer to groundwater	Same as above.
	PEST	CMAX	Maximum solubility of pesticide	Very sensitive. Affects proportions of soluble and sediment associated pesticide.
		X, K, N	Freundlich Isotherm parameters	Very sensitive. Determines proportions of soluble and adsorbed pesticide.

TABLE 5.7 (cont'd) SENSITIVE PARAMETER AND VARIABLE IMPLICATIONS IN NISSOURI WATERSHED MODEL

Module	Group	Parameter/ Variable	Explanation	Relative Sensitivity and Implications
PERLND	PEST	SDGCON, UDGCON LDGSON, ADGCON	Pesticide degradation rates in four soil layers	Very sensitive. Determines 'in situ' losses of pesticide.
		PEST-STOR	Initial mass of pesticide in soil layers and interflow	Very sensitive. Affects surface and subsurface runoff rates initially.
	PHOS	SKPLP, UKPLP LKPLP, AKPLP	Rates of plant uptake of phosphorus in 4 soil types	Minor sensitivity. Affects plant phosphorus levels and slight effect on runoff mass.
		X, K, N	Freundlich isotherm parameters	Very sensitive. Affects surface and subsurface runoff rates of phosphorus.
		KIMP	Phosphate immobilization	Moderate sensitivity. Affects subsurface phosphorus runoff.
		KMP	Organic phosphorus mineralization	Moderate sensitivity. Affects subsurface phosphorus runoff.
		PHOS-STORE	Initial organic, adsorbed, soluble and plant phosphorus in 4 soil layers	Moderate sensitivity. Affects all runoff rates and transformation rates.
RCHRES	HYDR	LEN	Reach length	Moderate sensitivity. Affects timing of hydrograph peaking.
		DELTH	Reach elevation change	Moderate sensitivity. Affects velocity and sediment transport.
		HYDR-INIT	Initial storage volume	Minor sensitivity. Determines initial outflow rate.

TABLE 5.7 (cont'd) SENSITIVE PARAMETERS AND IMPLICATIONS IN NISSOURI WATERSHED MODEL

Module	Group	Parameter/ Variable	Explanation	Relative Sensitivity and Implications
	SEDTRN	SDFG	Sand flag	Unknown sensitivity. Selects one of three methods for calculating sand transport.
		D, W, RHO	Diameter, settling velocity and density of sand, silt and clay	Moderate sensitivity. Used to calculate soil settling and transport capacity of flow.
		KSAND, EXPSND	Sandload capacity parameters	Very sensitive. Used in calculating sand settling and scour rates.
		TAUCD, TAUCS	Sheer stress limits for deposition and scour	Moderate sensitivity. Affects mass of silt and clay scouring and deposition.
		M	erodibility parameter	Very sensitive. Modifies scour and deposition of silt and clay.
		BED-INIT	Initial depth and composition of sediment	Moderate sensitivity. Affects available mass of sand, silt and clay for scouring.

tables. In addition, all parameters and initial conditions can be specified uniquely for each PLS or reach channel and altered during the simulation period through the 'Special Actions' block (see 5.5.3).

HSPF performs material balances within the soil column for phosphorus and pesticide. It does not balance soil but rather assumes that the soil supply is infinite. This is a reasonable assumption within the time frame of most simulations. The soil profile can be altered through the use of the Special Actions block if a drastic soil erosion or deposition event were to be simulated. Initial conditions specified for soil phosphorus and pesticide simulation include a description of soil layer depths, bulk densities, phosphorus concentrations and forms (organic, adsorbed, soluble, and plant phosphorus) and pesticide concentration and forms (crystalline, adsorbed, and solution). Soil layer depth should correspond approximately to those which are calculated by dividing the hydrologic soil water holding capacity depth from the PWATER module group by the porosity. Bulk density is calculated by particle density and interstitial water density. Bulk density measurements were made on surface and subsurface soils by BEAK in this study and by PLUARG (see Table 4.10).

Soil phosphorus concentrations were set in calibration but various sources of information provided first estimates. These include PLUARG soil sample analyses (see Table 4.10) as well as BEAK soil sample analyses (see Table 4.11). It was assumed that the majority of phosphorus was in the adsorbed or apatite form. Soil plant phosphorus for the upper layer (assumed to be the layer of most active crop growth) was modelled by calibrating plant uptake constants so that a realistic plant tissue phosphorus level was simulated over the growing season. Plant phosphorus levels for corn and mixed grains at full crop development were estimated to be about 15 to 20 kg/ha and 8 to 12 kg/ha respectively (PLUARG, 1978e). Soil organic phosphorus levels in the surface and upper layers were set to reflect some plant residue. Organic decay rates were calibrated to result in a reasonable annual balance of organic phosphorus, that is, there was no appreciable accumulation or depletion of this material in the long term. The application of fertilizers was simulated with an addition of phosphorus as organic phosphorus to the surface layer in the winter and solution phosphorus to the surface layer in the spring (see Section 5.5.3) according to general practices and levels reported by PLUARG (1978e).

Pesticide loads in the soil layers of corn fields were also set in calibration and were initially assumed to be in the adsorbed form in all layers. Residual levels in surface and sub-surface layers for the start of simulation on January 1 were measured in the field level studies conducted by MOE (see Appendix A) and on soil samples collected by BEAK (see Table 4.12). Pesticide in situ decay rates were set in the model to reflect the observed time dependent decrease of pesticide concentration levels as measured by MOE in field plot studies (see Appendix A).

Table 5.8 lists the initial conditions for phosphorus and atrazine levels as used in the calibrated model and soil layer depths and bulk densities used throughout the simulations.

5.5.3 Special Actions

Land management activities such as tillage or fertilization result in the sudden alteration of process parameters and state variables. As an example, when a farmer tills a field using a moldboard plow he affects a number of factors which in turn affect runoff, erosion and agri-chemical movement by loosening the surface and upper soil layers, increasing the surface roughness, increasing infiltration rates, reducing plant cover, mixing the surface layer into the soil matrix, and increasing the amount of detached soil available for erosion. All of these factors can be changed in a stepwise manner using the "Special Actions" facility in HSPF. This block of information replaces or increments any process parameters or state variables at a specified time, until readjusted or modified by internal processes. This facility allows for the superposition of land management practices onto the land area and therefore the testing of various alternative practices with HSPF.

Table 5.9 lists the land management practices, affected areas and parameters altered in the 1985 and 1986 simulation of the Nissouri Creek Watershed runoff, erosion and agri-chemical movement.

Other special actions can and have been used to reflect significant natural events such as a thawing period in winter which results in surface soil layer melting and increased infiltration and alterations to pesticide degradation rates due to seasonal temperature changes (pesticide decay rates are not normally temperature dependent in the version 8.0 of HSPF).

TABLE 5.8

SOIL DEPTHS, BULK DENSITIES AND INITIAL PHOSPHORUS AND PESTICIDE SOIL CONCENTRATIONS USED IN MODELLING

Soil Layer	Slope Class %	Depth (mm)	Bulk Density (gm/cm^3)	Phosphorus Conc. (kg/ha) Org. P.	Ads. P.	PO4-P	Plant P.	Atrazine Conc. (kg/ha) Cryst.	Ads.	Soln.
Surface	all	10	1.30	20.	340.	0.0	1.0	0.0	0.025	0.0
Upper	all	80	1.32	25.	800.	0.0	1.0	0.0	0.10	0.0
Lower	0-0.5	250	1.33	15.	2,500.	0.0	0.5	0.0	0.07	0.0
	0.5-2.0	400	1.33	15.	4,000.	0.0	0.5	0.0	0.11	0.0
	2.0-5.0	650	1.33	15.	6,500.	0.0	0.5	0.0	0.17	0.0
	GT 5.0	1,000	1.33	15.	10,000.	0.0	0.5	0.0	0.27	0.0
Groundwater	all	300	1.33	3.	2,000.	0.1	0.5	0.0	0.4	0.0

TABLE 5.9 SPECIAL ACTIONS RESULTING FROM LAND MANAGEMENT PRACTICES, 1985 & 1986

Date	Activity	Affected Areas	Affected Parameters
02/01	Manure spreading of organic phosphorus	All cultivated fields	Surface layer organic phosphorus levels
04/19	Land spreading of pre-plant pesticide	All corn fields	Surface layer pesticide levels
05/05	Land spreading of pre-plant pesticide	All corn fields	Surface layer pesticide levels
05/10	Land spreading of pre-emergent pesticide	All corn fields	Surface layer pesticide levels
05/10	Tillage	All cultivated fields	Infiltration rates
05/11	Fertilization	All cultivated fields	Surface layer soluble phosphorus levels
05/18	Post-emergent spreading of pesticide	All corn fields	Surface layer pesticide levels
05/25	Post-emergent speading of pesticide	All corn fields	Surface layer pesticide levels
09/30	Harvesting mixed grains	All mixed grain fields	Surface and upper layer organic and plant phosphorus levels
11/01	Harvesting corn	All corn fields	Surface and upper layer organic and plant phosphorus levels
11/10	Spreading post-harvest pesticides	All corn fields	Surface layer pesticide levels

5.6 Calibration/Verification

5.6.1 Approach

The calibration/verification process is a systematic one in which model complexity is gradually added. Firstly, the hydrologic portions of the model (SNOW, PWATER and HYDR) were calibrated using the 1985 TSS. It is essential that a reliable calibration is achieved at this stage since all sediment and agri-chemical processes are "piggy backed" onto the hydrologic model. The second stage involved the soil erosion and sediment transport modules (SEDMNT and SEDTRN). Next, soil temperature and moisture modules (PSTEMP and MSTLAY) were calibrated. The agri-chemical sections (PEST and PHOS) were calibrated last and separately. These sections require accurate hydrologic and soil erosion predictions as well as simulated soil temperature and moisture in order to realistically simulate the sediment associated runoff of chemicals, soil matrix transformations (i.e., decay, and mineralization) and solute percolation and outflow. Errors in calibration at any early stage will be compounded in the agri-chemical sections. All calibration was completed on the 1985 data set.

In order to evaluate model simulation results, various intermediate time series were displayed. These time series are generally information which is only examined during calibration and is not a final simulation product. This type of output includes such variables as water content of the snowpack and evaporation from the snowpack (from section SNOW); surface, upper, lower and groundwater storage (from section PWATER); and amounts of pesticide that is adsorbed, in solution or in a crystalline form in all the soil layers (for section PEST). If the simulation of any of these intermediate processes is in error for any reason, then this fact will be apparent in terms of the quantity of water or chemical in a particular compartment. For example, if unreasonably high evaporation rates are simulated, then the simulated snowpack water content will decrease at an unreasonable rate and the pack will be reduced to unrealistic depths throughout the winter months. This error would also result in an underestimation of spring runoff volumes. Problems of this nature can be tracked and isolated by reviewing various intermediate state variables and process rates.

Several intermediate state variables and fluxes were reviewed during the calibration/verification process but the main evaluation was made by comparing observed water quality and quantity at the four surface water monitoring sites to predicted values. All hourly output was aggragated to yield daily total flows and loads. This time frame was selected since all observed water quality loading data is in a daily form. Also, prediction of the exact time of a short lived response is of less concern than the impact that it has. That is, the simulation goal is to accurately predict the quantity of water, soil, and certain chemicals which runoff and the correct balance among pathways. The exact timing, within a period of hours, is of less overall importance.

After reasonable results were achieved in calibrating the model with 1985 inputs for all parameters, the model was run with the 1986 input data. Some adjustments were made in the discretization scheme to reflect 1986 land use and in the "special actions" block to reflect changes in farm operations. In addition, initial conditions for 1986 were set to reflect the final simulated conditions of 1985. In the first run, results were not as good as for the 1985 runs and therefore alterations were made to the most sensitive model parameters in order to optimize the degree of correspondence between observed and predicted flows and loads in both years. An iterative process was employed in this manner until a single set of model parameters was found which resulted in reasonable simulation results for both years.

This model testing scheme results in a partial verification. True verification requires that no further adjustment of model parameters take place when the model is applied to a different data set, independent in terms of location and/or time. The 1986 data set was used to aid in model calibration in this case and therefore unconditional verification is not possible. Partial verification has been achieved in that several model simulation processes required no adjustment after the 1985 runs and the model has demonstrated a capability to perform a balanced simulation over two complete and dissimilar years. It is the opinion of the study team that the objectives of this study are better served by a well calibrated, partially verified model rather than a poorly verified version and therefore the 1986 dataset was used to improve calibration rather than solely for verification.

5.6.2 Hydrology

The results of calibration/verification are illustrated in Figures 5.6 through 5.11 in terms of daily total predicted and observed streamflow at stations N1, N2 and N3, for 1985 and 1986. Surface runoff only was monitored at Station N4 and is therefore predictions are

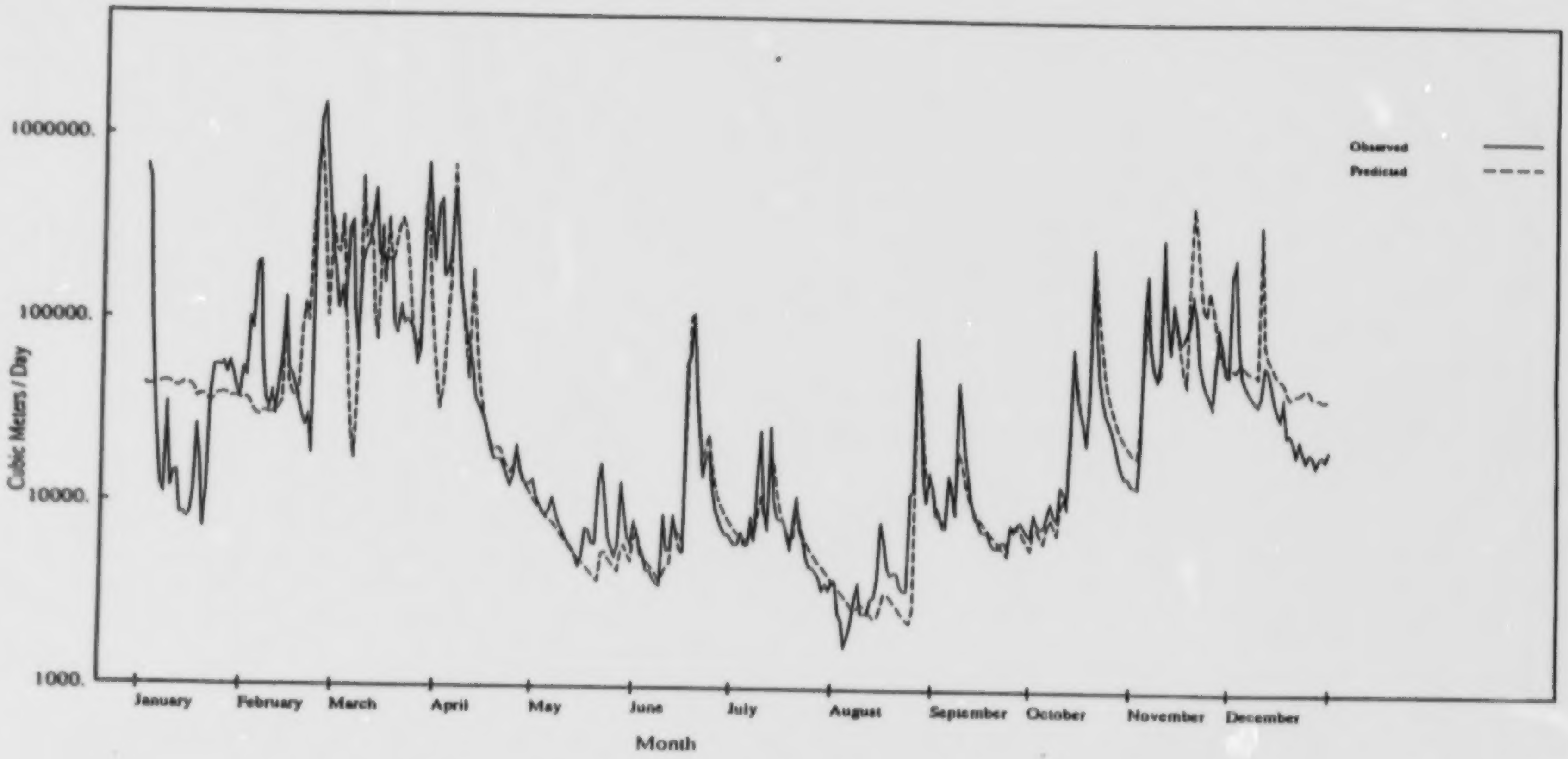


Figure 5.6 Stn. N1 Predicted and Observed Total Daily Flow,1985

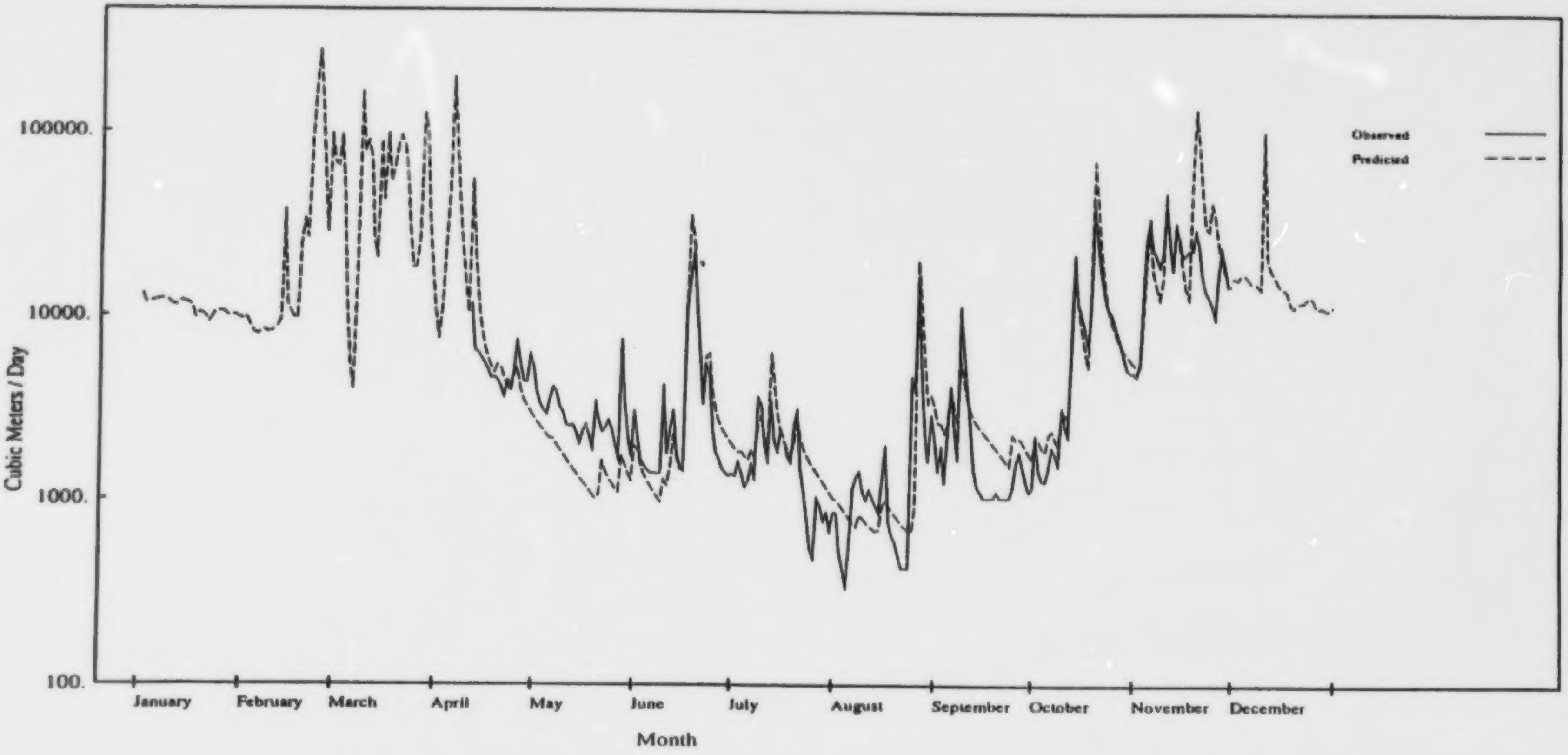


Figure 5.7 Stn. N2 Predicted and Observed Total Daily Flow,1985

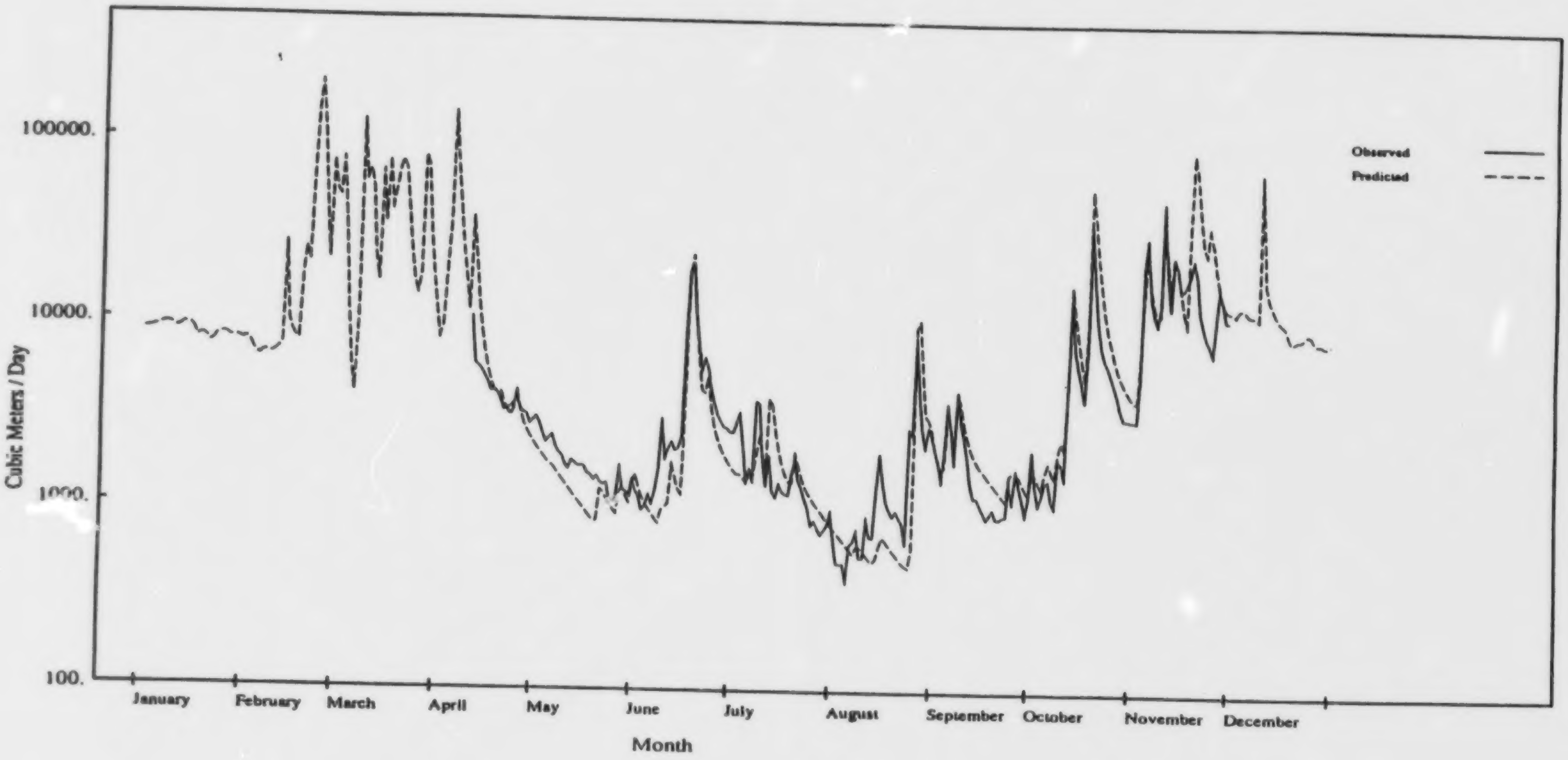


Figure 5.8 Stn. N3 Predicted and Observed Total Daily Flow,1985

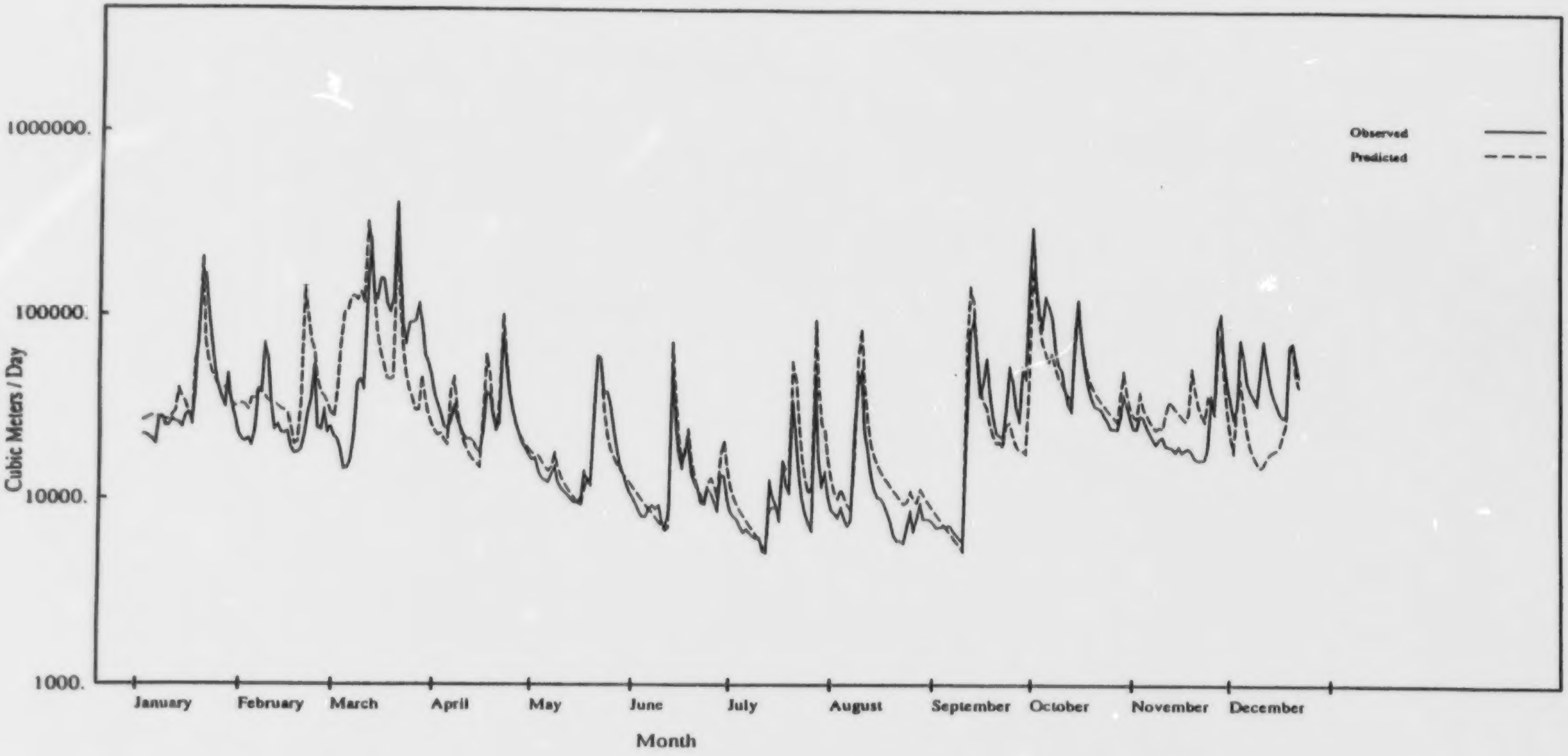


Figure 5.9 Stn. N1 Predicted and Observed Total Daily Flow,1986

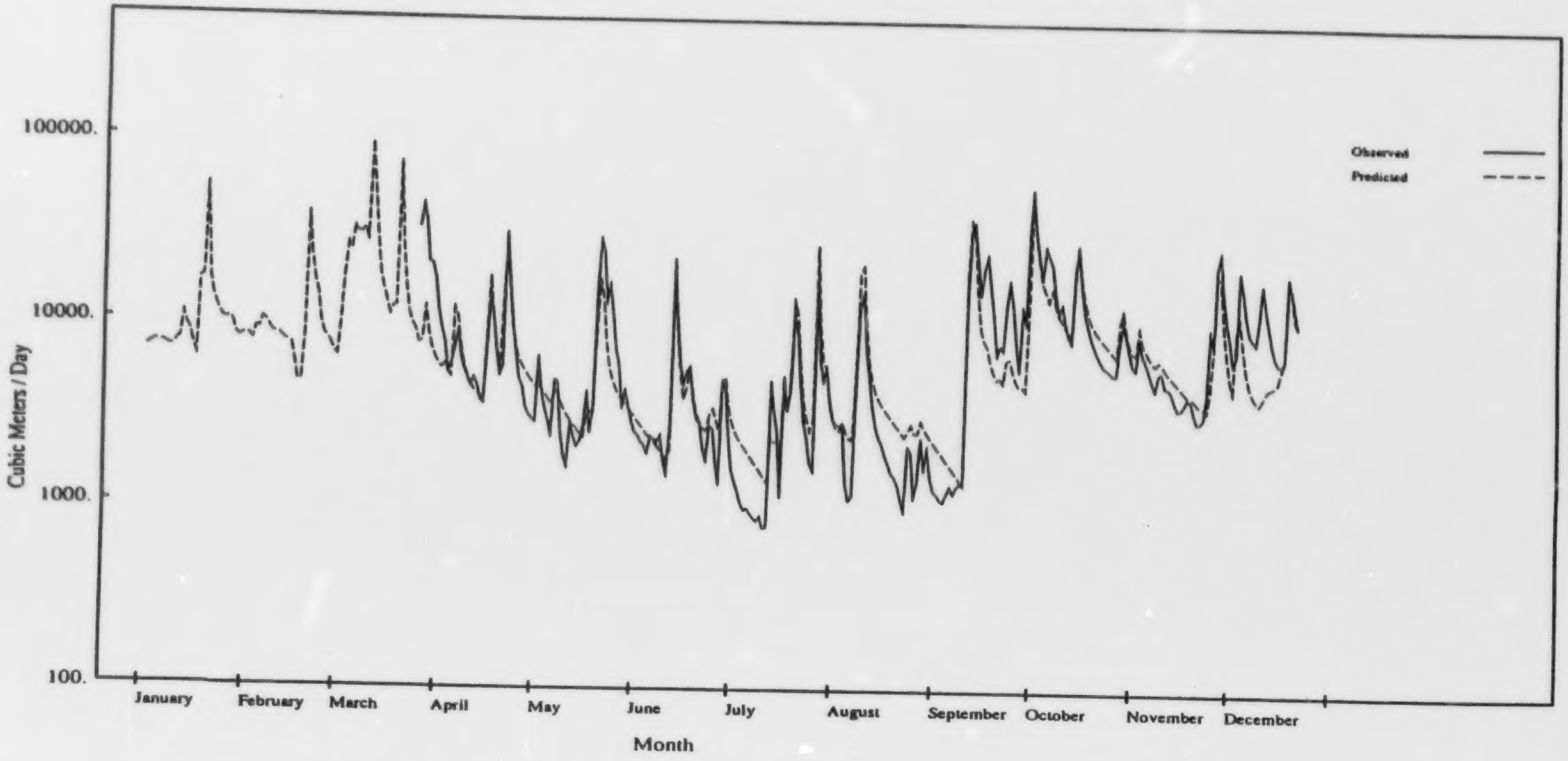


Figure 5.10 Stn. N2 Predicted and Observed Total Daily Flow,1986

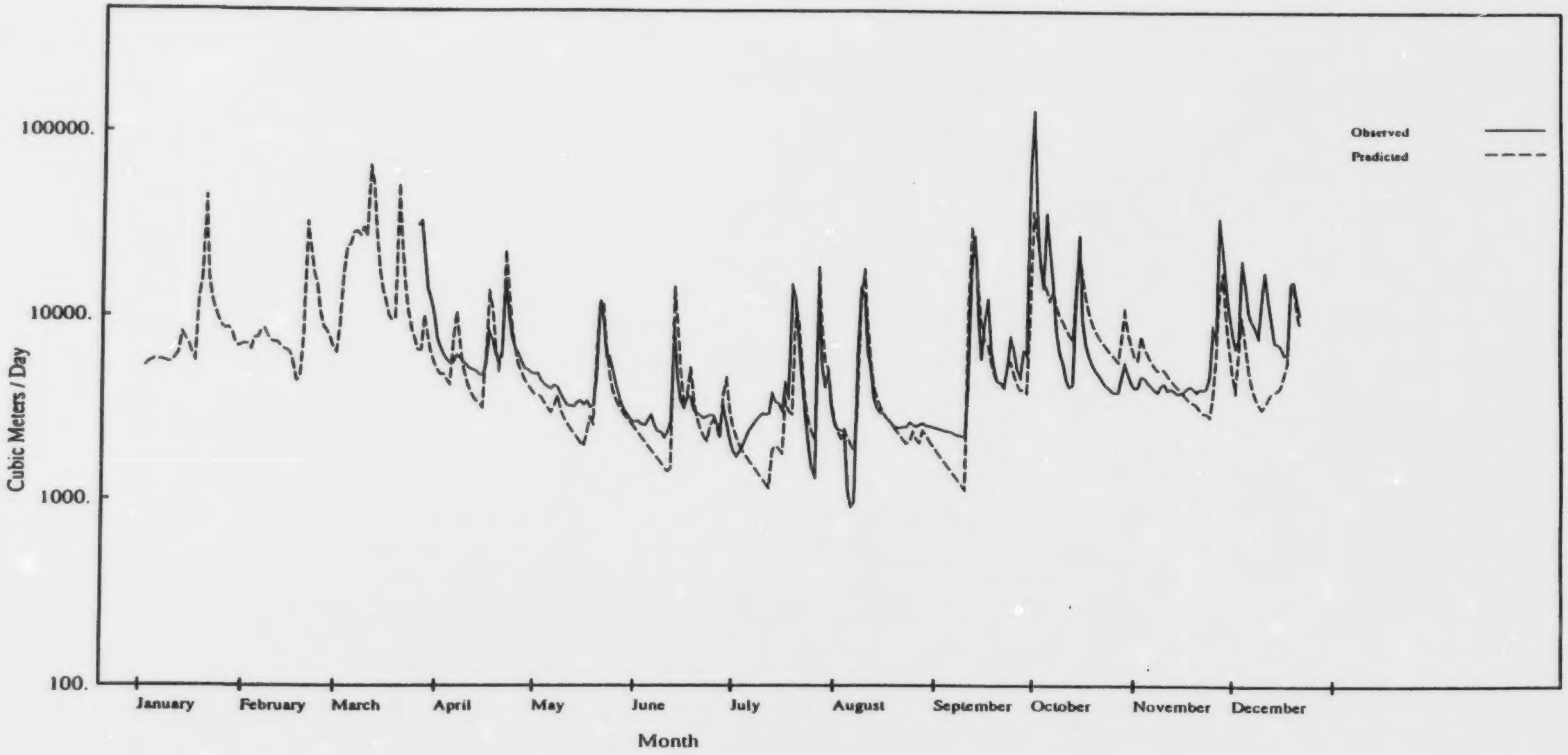


Figure 5.11 Stn. N3 Predicted and Observed Total Daily Flow,1986

not comparable in these terms. Stations N2 and N3 were operated during ice free periods only. In general, correspondence is very good. The early part of the 1985 period for station N1 displays some discrepancy. This is most likely due to errors in the observed data set due to freezing in the stilling well. Springtime snowmelt events correspond well in terms of magnitude and frequency but differ in timing. The spring, summer and fall events are well represented by the model estimates. The 1986 predictions are also very good at all stations. The largest discrepancies in 1986, like in 1985, occur during winter and during the short winter freeze up and spring thaw periods. Snowmelt and accumulation, and freezing and thawing in the soil matrix introduce considerable modelling complexity and prediction error. The apparent errors are largely timing errors while the overall water balance is good.

Table 5.10 summarizes predicted and observed streamflow by month for three stations. Predicted monthly and annual total flows are in excellent agreement in all areas, usually within 10% of the observed despite monthly variation by a factor of twenty-five.

Table 5.11 lists final calibrated values for the key hydrologic parameters of HSPF as identified in Table 5.7 earlier. The Addendum contains complete UCI listings. These should be referenced for detailed information on parameters which vary by month or PLS.

Apparent calibration errors can be the result of various factors including:

- errors in observed data (i.e., precipitation and streamflow),
- unknown land management activities,
- temporal and spatial variability of soil characteristics on a micro scale unaccounted for due to attribute lumping,
- averaging of non-linear processes,
- modelling oversimplification of processes,
- inaccurate calibration values, and
- fundamental error in model algorithms.

It must be accepted that some or all of these factors apply in any modelling exercise. Those factors which are controllable have been minimized in calibration. Further calibration, system discretization and model complexity could result in even better

TABLE 5.10 MONTHLY OBSERVED AND PREDICTED STREAMFLOW, 1985-86

Year	Month	Station N1 Flow (m^3 x 10^6)		Station N2 Flow (m^3 x 10^6)		Station N3 Flow (m^3 x 10^6)	
		Observed	Predicted	Observed	Predicted	Observed	Predicted
1985	Jan.	2.19	1.25	-	.340	-	.265
	Feb.	6.28	4.22	-	1.17	-	.885
	March	6.62	6.34	-	1.73	-	1.34
	April	2.73	2.49	-	.663	-	.538
	May	0.25	0.21	.090	.057	.053	.045
	June	0.49	0.55	.123	.153	.134	.116
	July	0.25	0.25	.051	.068	.050	.053
	Aug.	0.28	0.25	.059	.069	.048	.050
	Sept.	0.33	0.29	.063	.081	.049	.061
	Oct.	1.03	1.28	.270	.326	.181	.287
	Nov.	2.58	3.13	.624	.846	.473	.672
	Dec.	1.44	1.89	-	.521	-	.393
1985	Total	24.5	22.2	-	6.02	-	4.71
1986	Jan.	1.31	1.31	-	.339	-	.282
	Feb.	0.80	1.15	-	.283	-	.259
	March	2.97	2.73	-	.698	-	.010
	April	0.83	0.92	.220	.238	.189	.201
	May	0.59	0.56	.198	.148	.134	.119
	June	0.39	0.46	.117	.120	.091	.098
	July	0.38	0.56	.112	.143	.131	.116
	Aug.	0.38	0.53	.094	.140	.110	.113
	Sep.	1.35	0.87	.407	.227	.371	.183
	Oct.	1.71	1.73	.412	.451	.308	.371
	Nov.	0.86	0.76	.213	.202	.205	.162
	Dec.*	0.65	0.58	.160	.151	.152	.123
1986	Total	12.2	12.2	-	3.14	-	2.63

- Not available
* Until December 21 only

TABLE 5.11

CALIBRATED HSPF PARAMETER VALUES FOR HYDROLOGIC MODULE (PERLND)

Module Group	Parameter	Explanation	Calibrated Value
SNOW	COVIND	snow pack depth at complete coverage	20.0 mm
	CCFACT	snow condensation/convection melt rate parameter	1.5
	MWATER	maximum water content of snow pack ratio	0.050
	MGMELT	depth of water equivalent of pack which melts by ground heat	1.40 mm/d
PWATER	LZSN[1]	lower soil zone nominal storage	75.0-250.0 mm
	LSUR[1]	length of overland flow phone	20-680 m
	SLSUR[1]	slope of PLS's	0.025-0.70 m/m
	AGWRC	groundwater recession rate	0.95/day
	CEPSC[1,2]	interception storage capacity	0-5.0 mm
	UZSN[2]	upper soil zone nominal storage	15.0-20.0 mm
	NSUR[2]	Manning's roughness factor	.15-.25
	INTFW[1]	Interflow inflow parameter	2.0-6.0
	IRC[1,2]	Interflow recession parameter	0.2-0.7
	INFILT[2]	Infiltration capacity	.009-1.14 mm/hr

[1] Varies by PLS type
[2] Varies by month

results. However, the law of diminishing returns applys. That is, much more effort, at this stage, can be expected to yield modest returns. We believe that the results at this stage are good and the model is suitable for hydrologic simulations.

5.6.3 Sediment - Soil Loss

Surface overland runoff results in erosion and sediment transport which is manifested in streams as high suspended sediment loads. Observed daily sediment loads were estimated for about 50 to 60 days per year. Most of the estimated daily loads are for runoff event periods and about 8 to 12 daily loads are for baseflow periods. Figures 5.12 through 5.17 are plots which compare the predicted and observed daily suspended sediment loads at stations N1 (all year), and stations N2 and N3 (ice free period) for 1985 and 1986.

Considering the complexity of the erosion - sediment transport process, these results are reasonable. Daily predicted and observed loadings are generally within a factor of 2 and therefore accuracy is ±50% on a daily basis. Predictions for late May, early June and October of 1985 and most of 1986 are very good despite a range of observed loadings which spans four orders of magnitude. It should be noted that errors in baseflow loadings are insignificant in the context of the whole year since baseflow loads do not contribute significantly to annual loadings. The timing of sediment loads is complicated by the fact that sediment can be deposited in the stream following an event and scoured at a later time. While sediment deposition and scour in channels is simulated, very little field data is available to verify this component of the model. The deposition and scour terms were calibrated so that no significant net accumulation or scour was predicted over an annual period.

Table 5.12 summarizes the predicted watershed soil losses by month. The 1985 loadings occurred primarily in the spring snowmelt period and late in the year when vegetative cover was low. The higher daily loadings predicted in 1986 occurred during major events in July and September. The 1986 events resulted in lower monthly loads than those observed at any time in 1985. The largest predicted event soil loss for 1985 and 1986 respectively was 308 tonnes (April, 1985) and 63.5 tonnes (July, 1986). Very low daily sediment transport values are predicted in months with no major surface runoff and are largely due to sediment scour in channels. Soil loss in 1986 is predicted to be only one quarter of the soil loss in 1985.

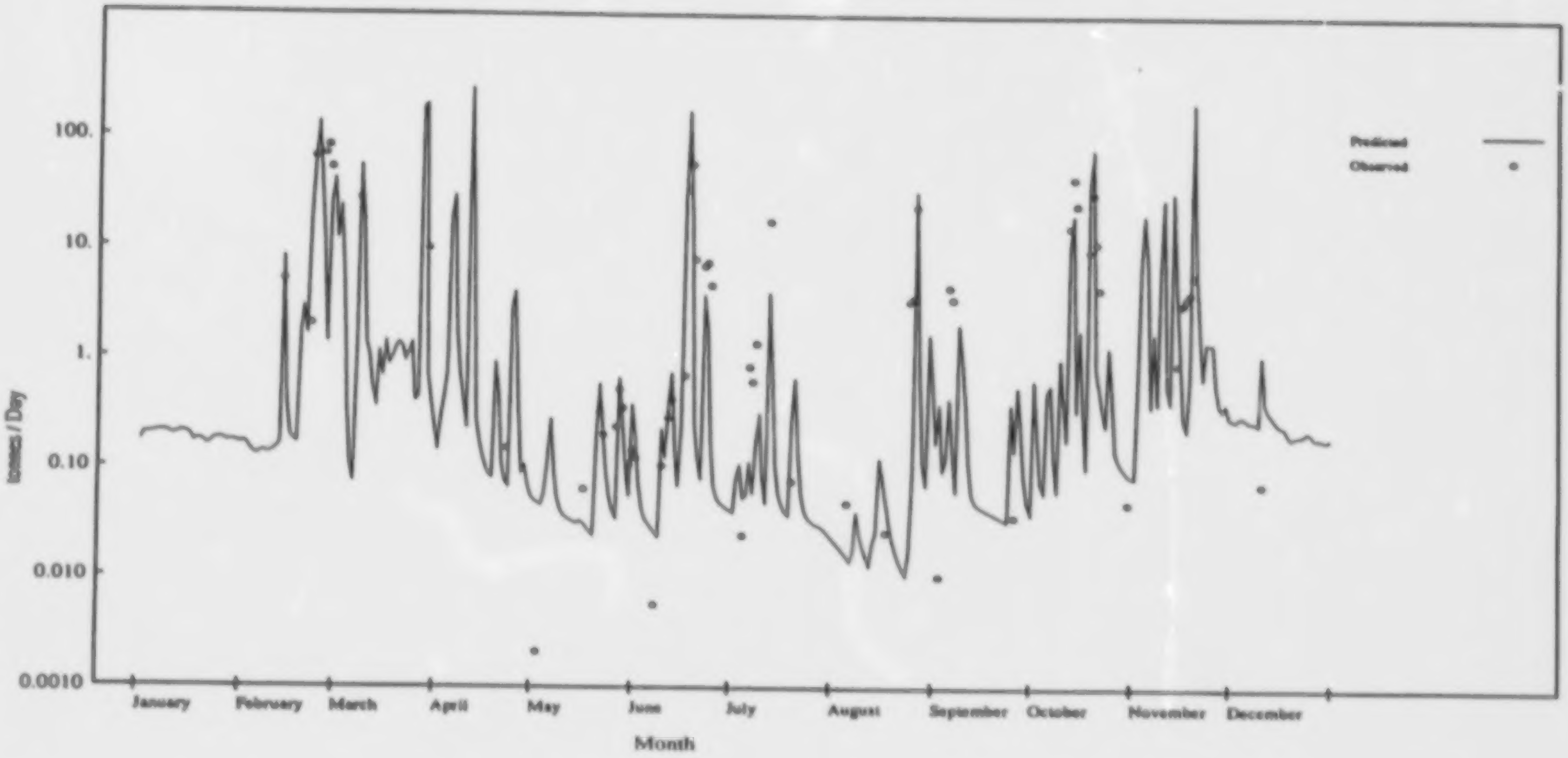


Figure 5.12 Stn. N1 Predicted and Observed Total Daily Suspended Sediment Load, 1985

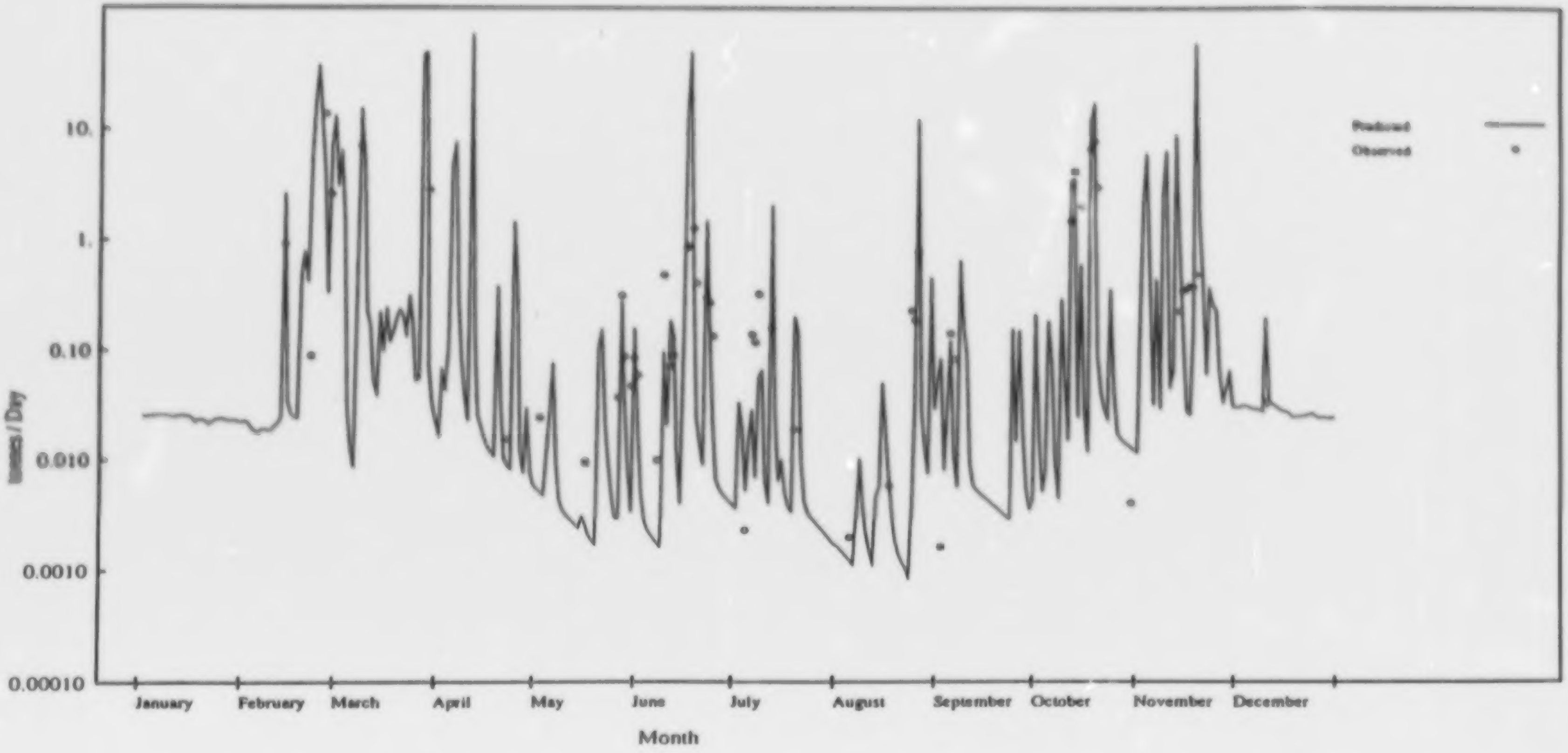


Figure 5.13 Stn. N2 Predicted and Observed Total Daily Suspended Sediment Load,1985

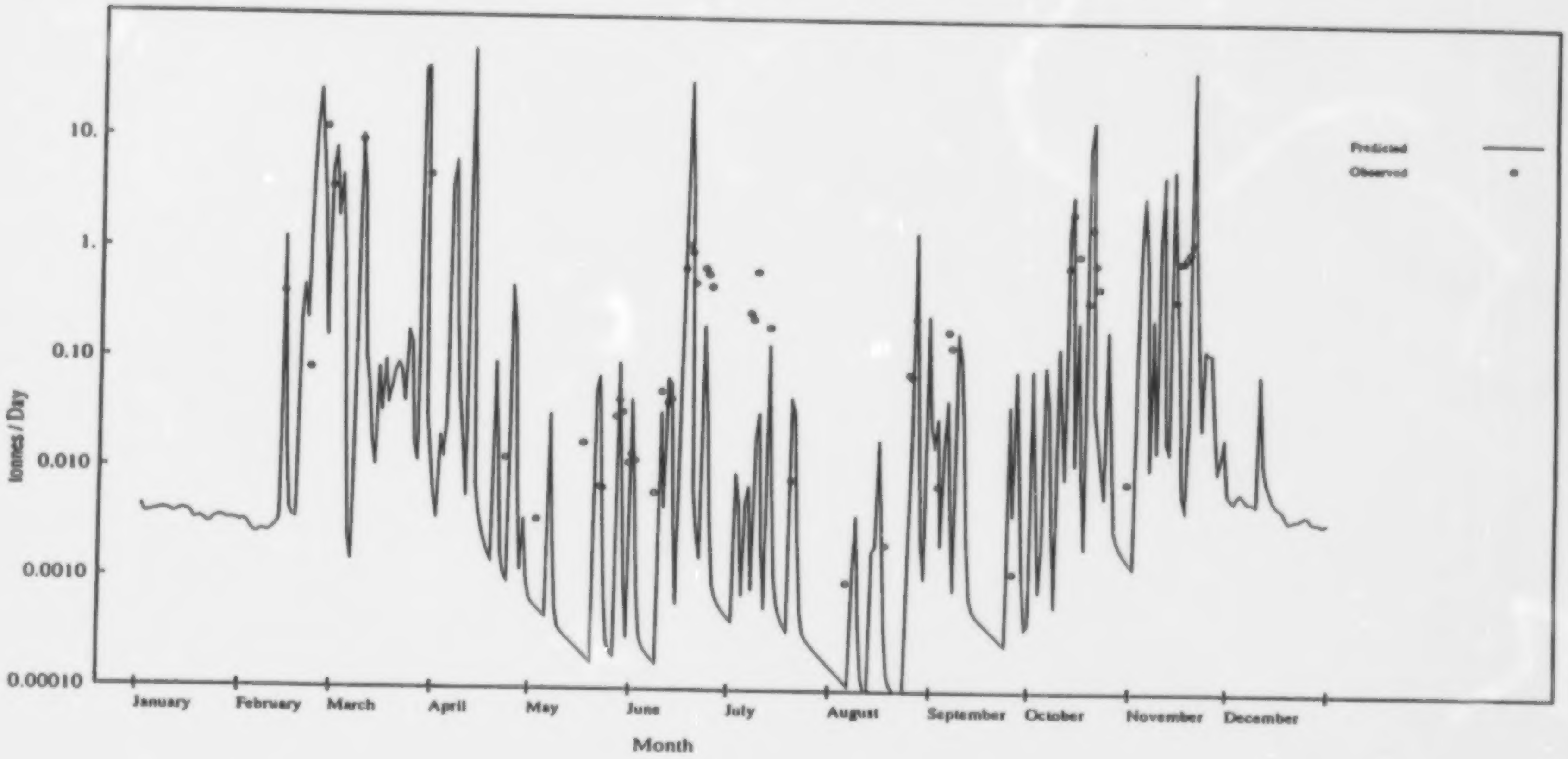


Figure 5.14 Stn. N3 Predicted and Observed Total Daily Suspended Sediment Load, 1985

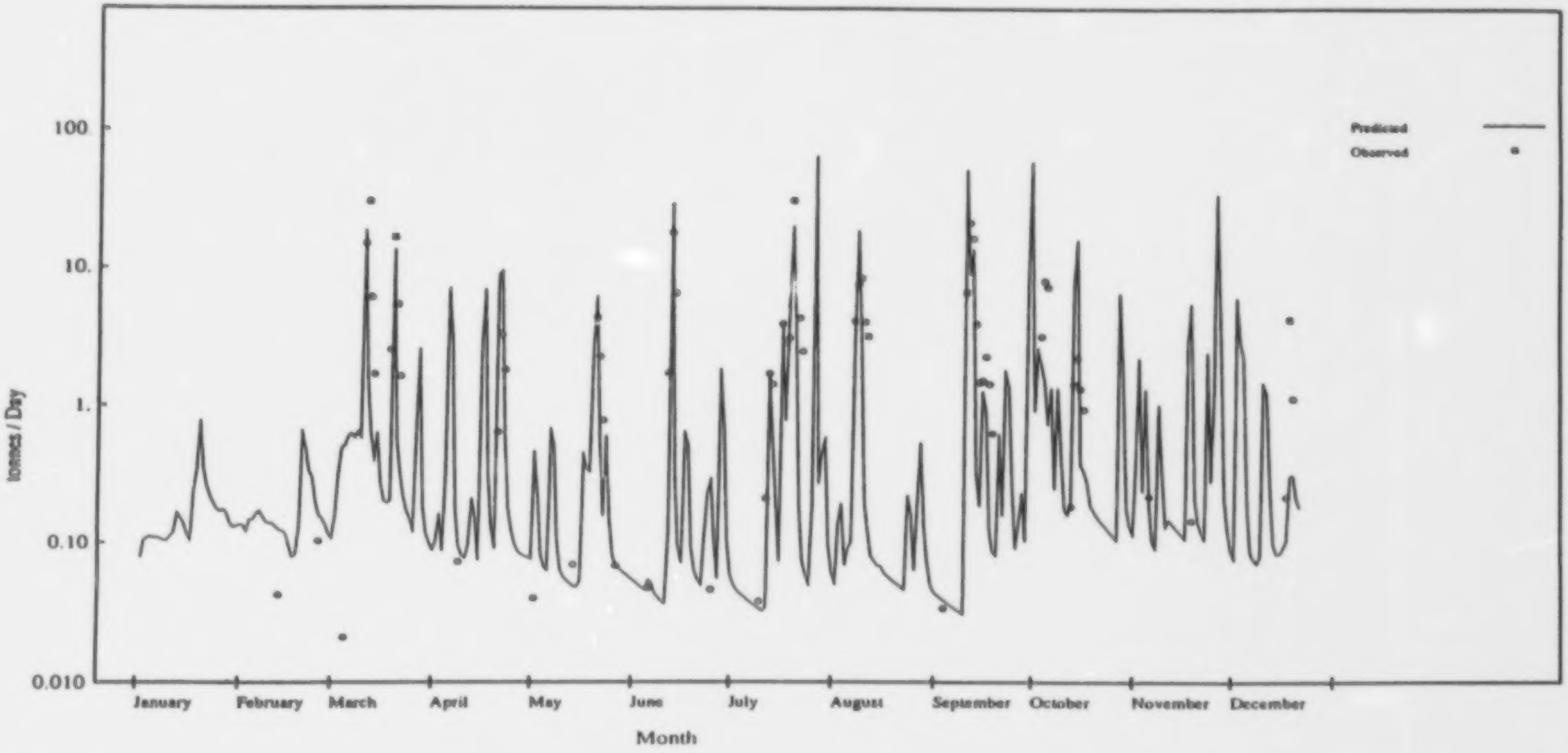


Figure 5.15 Stn. N1 Predicted and Observed Total Daily Suspended Sediment Load, 1986

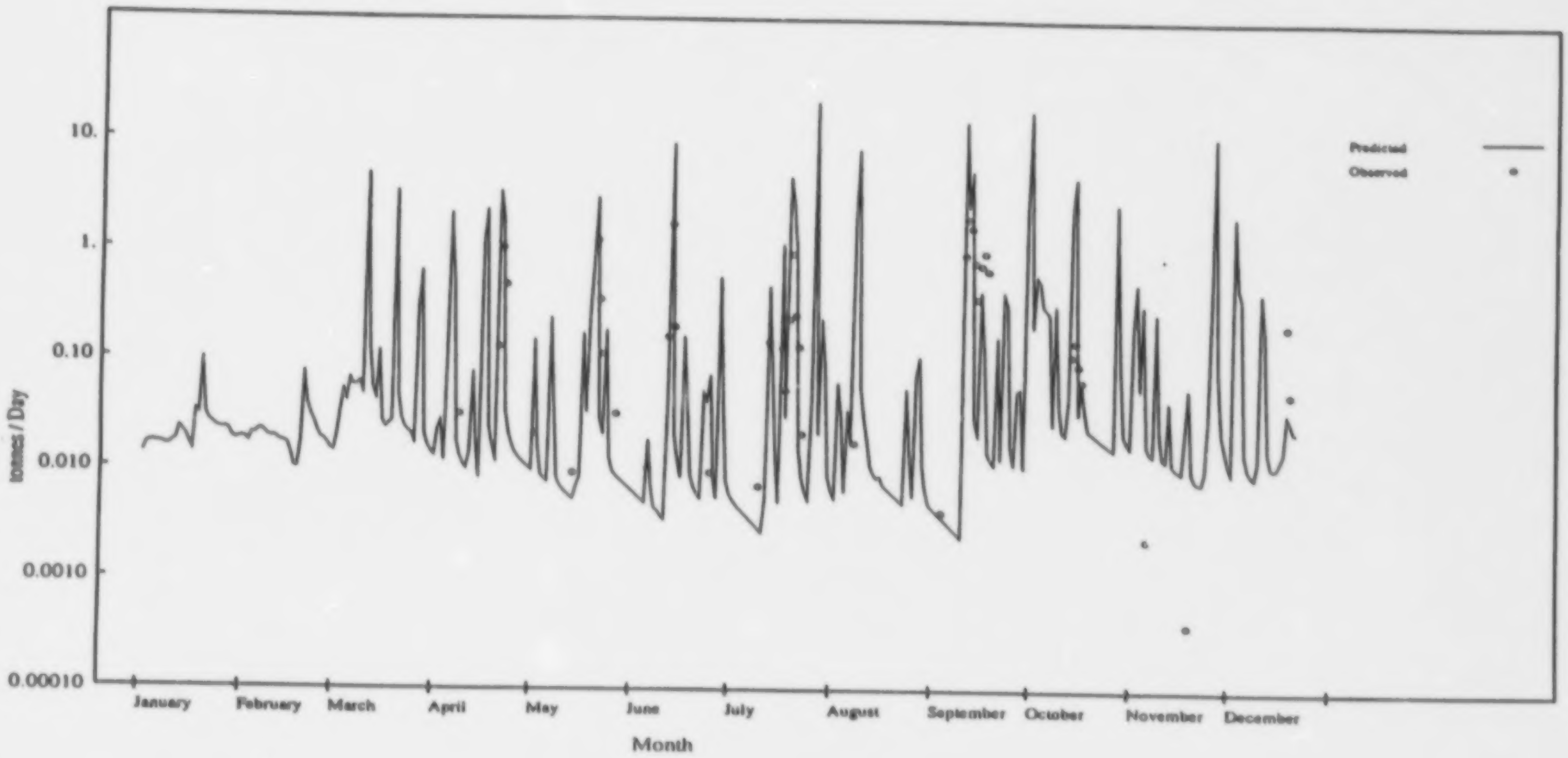


Figure 5.16 Stn. N2 Predicted and Observed Total Daily Suspended Sediment Load, 1986

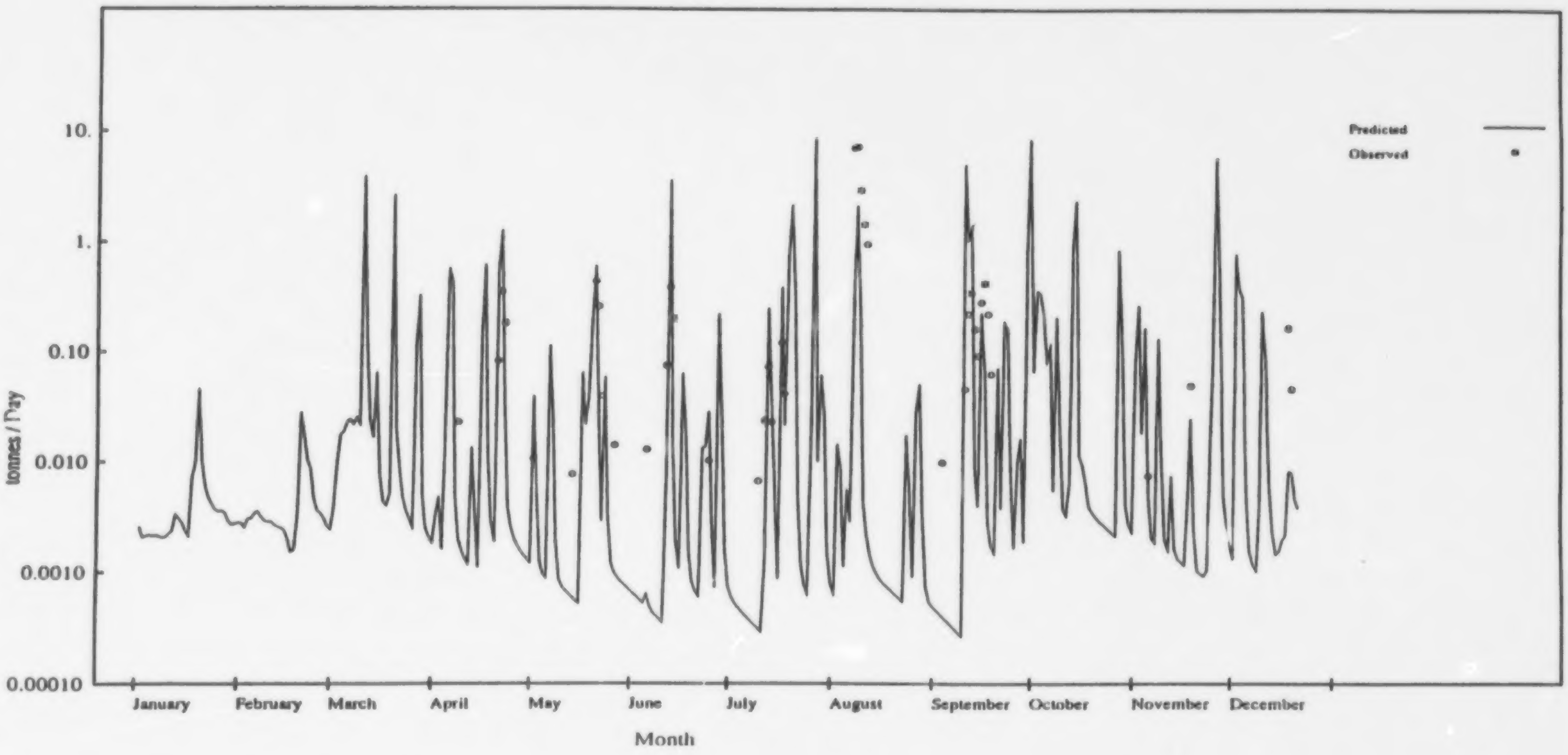


Figure 5.17 Stn. N3 Predicted and Observed Total Daily Suspended Sediment Load, 1986

TABLE 5.12 MONTHLY PREDICTED SOIL WASHOFF

Year	Month	Soil Loss - Sediment Transport (tonnes)
1985	January	0
	February	352
	March	503
	April	366
	May	8.07
	June	253
	July	9.36
	August	42.5
	September	9.57
	October	178
	November	353
	December	0
1985 Total		2,074
1986	January	5.49
	February	5.00
	March	46.7
	April	42.0
	May	14.5
	June	35.2
	July	104
	August	28.1
	September	150
	October	46.6
	November	47.1
	December	-
1986 Total		525

Table 5.13 lists the final calibrated HSPF parameter values for the same sensitive parameters identified in Table 5.7. The Addendum contains complete UCI listings. These should be referenced for detailed information on parameters which vary by month and PLS.

5.6.4 Phosphorus Loss

As with soil loss the observed phosphorus loading data takes the form of daily loads measured on 50 to 60 days in each year of the field program.

Figures 5.18 through 5.23 illustrate how HSPF predictions of daily total phosphorus compare with observed data for stations N1, N2 and N3 in 1985 and 1986. Observed loads span 4 orders of magnitude over the study period.

The calibration results are felt to be very good, especially in the summer months of 1986 when daily loadings range from less than 1 kg to over 200 kg in response to an event. As is the case with soil loss, daily loadings are highly variable and recover to low values very quickly following an event. Predicted values are generally within a factor of two and therefore prediction accuracy is ±50% over the simulation period.

It is assumed in HSPF that phosphorus is a conservative constituent of the streamflow and therefore all phosphorus which enters the channels (dissolved and sediment associated) is transported to the watershed mouth. This is a reasonable assumption in the long term especially in headwater streams. Baseflow loads are due to tile drain outflow and groundwater seepage of dissolved phosphorus.

Table 5.14 summarizes monthly predicted phosphorus loadings for the study period. The 1985 loads were much higher than in 1986 due to more extreme erosion events, especially in the spring and fall of 1985 and tend to reflect the predicted soil loss patterns. These results are discussed in Section 5.7.

Table 5.15 lists calibrated values for key model parameters as identified in Table 5.7. The Addendum contains complete listings of UCI values including all monthly and PLS variable parameters.

TABLE 5.13

CALIBRATED HSPF PARAMETER VALUES FOR SOIL-SEDIMENT MODULES

Module	Group	Parameter	Explanation	Calibrated Value
PERLND	SEDMNT	SMPF	supporting management practice factor	1.0
		KRER	soil detachment parameter - constant	0.15-0.42
		JRER	soil detachment parameter - exponent	1.7
		KSER	soil washoff parameter - constant	.15 - 2.7
		JSER	soil washoff parameter - exponent	0.8
		AFFIX	rate of soil reattachment	0.50/day
		COVER[1,2]	vegetative cover ratio	0.05 - 0.80
RCHRES	SEDTRN	KSAND	sand load capacity parameter	0.50
		EXPSND	sand load capacity exponent	0.60
		TAUCD	shear stress below which deposition of silt and clay occurs	1.8, 0.8 kg/m^2
		TAUCS	shear stress above which settling of silt and clay occurs	1.8, 0.8 kg/m^2
		M	erodibility of sediment silt, and sedimentclay	0.02, 0.002 kg/m^{2}d

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[1] Varies by PLS

[2] Varies by month

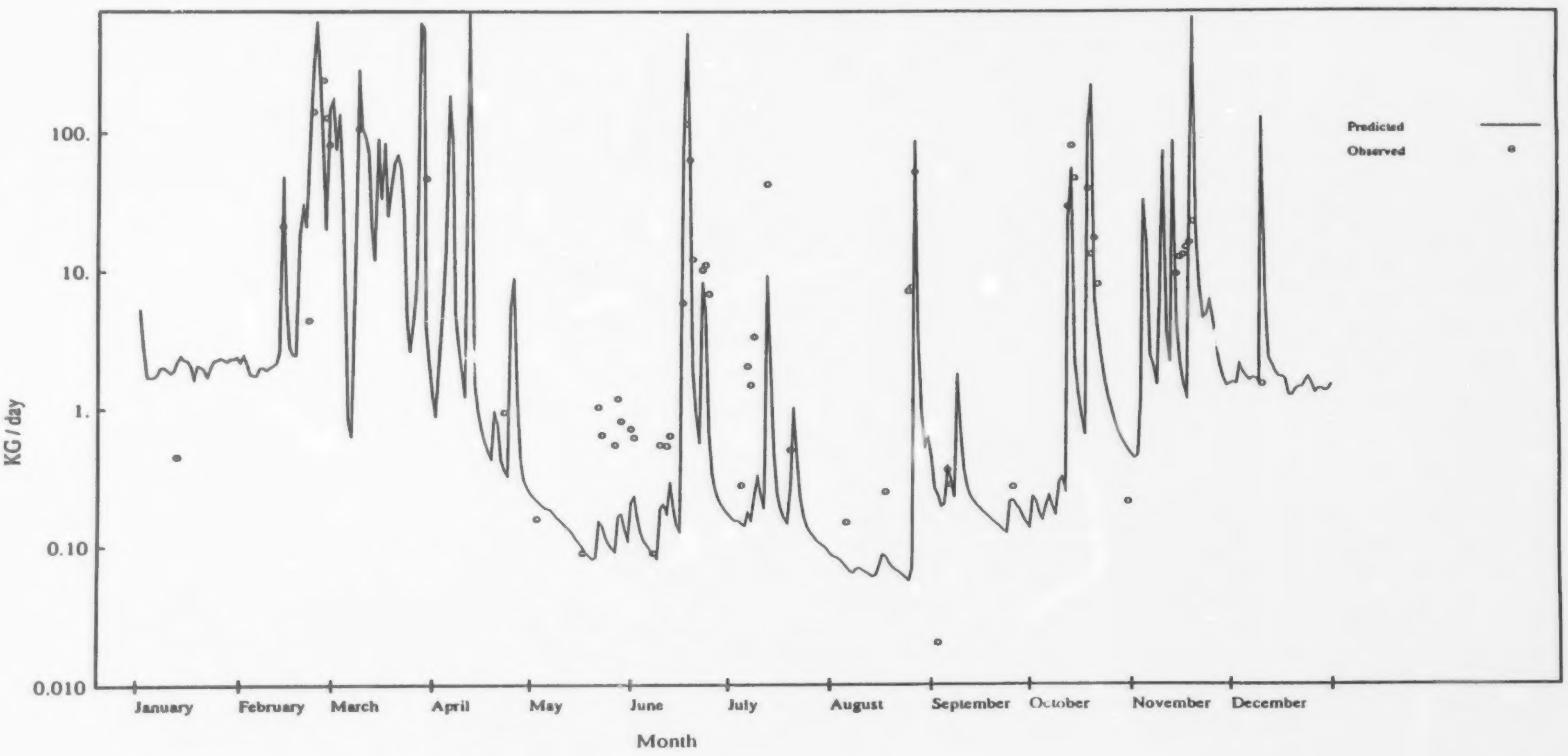


Figure 5.18 Stn. N1 Predicted and Observed Total Daily Phosphorus Load, 1985

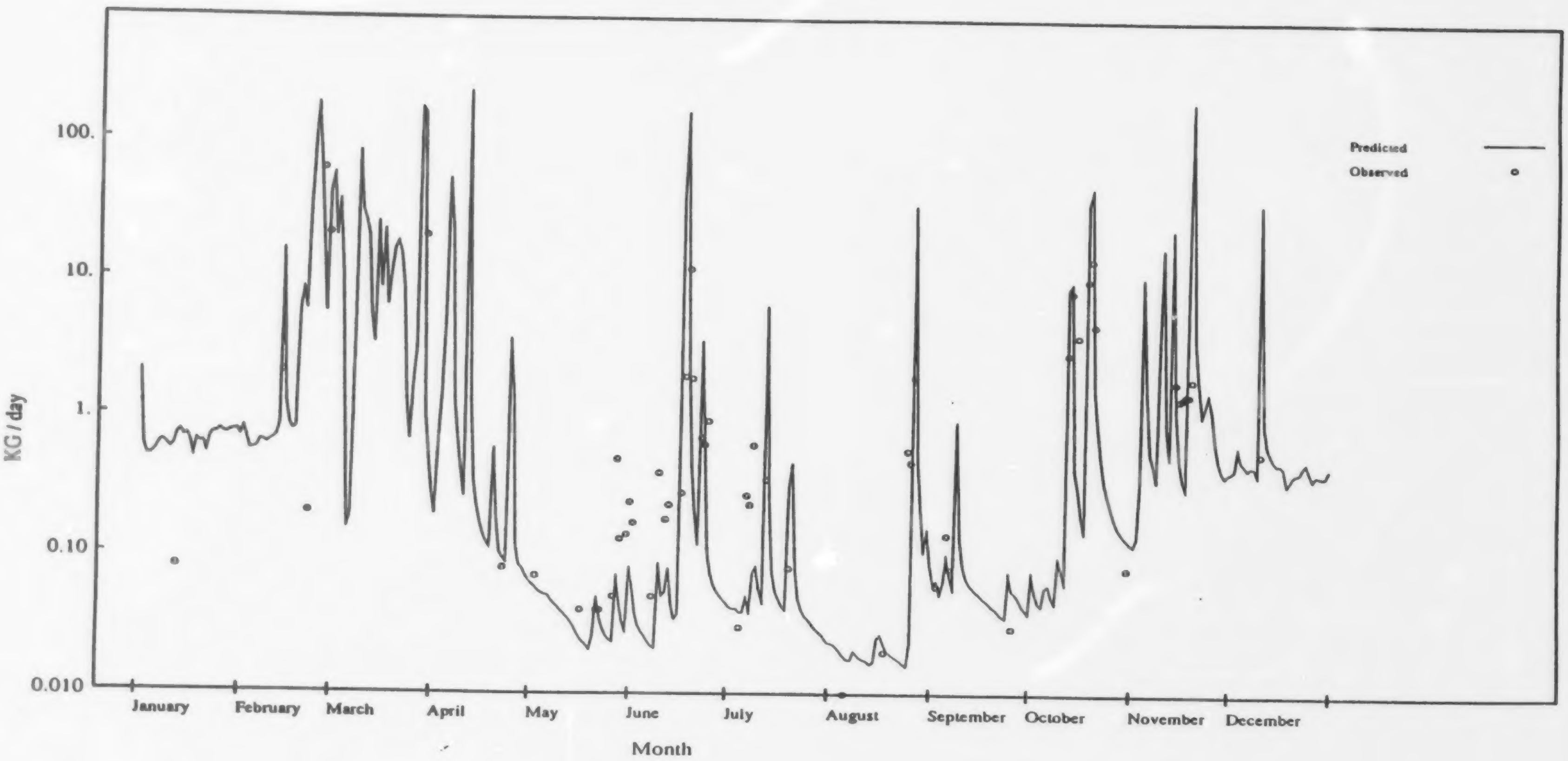


Figure 5.19 Stn. N2 Predicted and Observed Total Daily Phosphorus Load, 1985

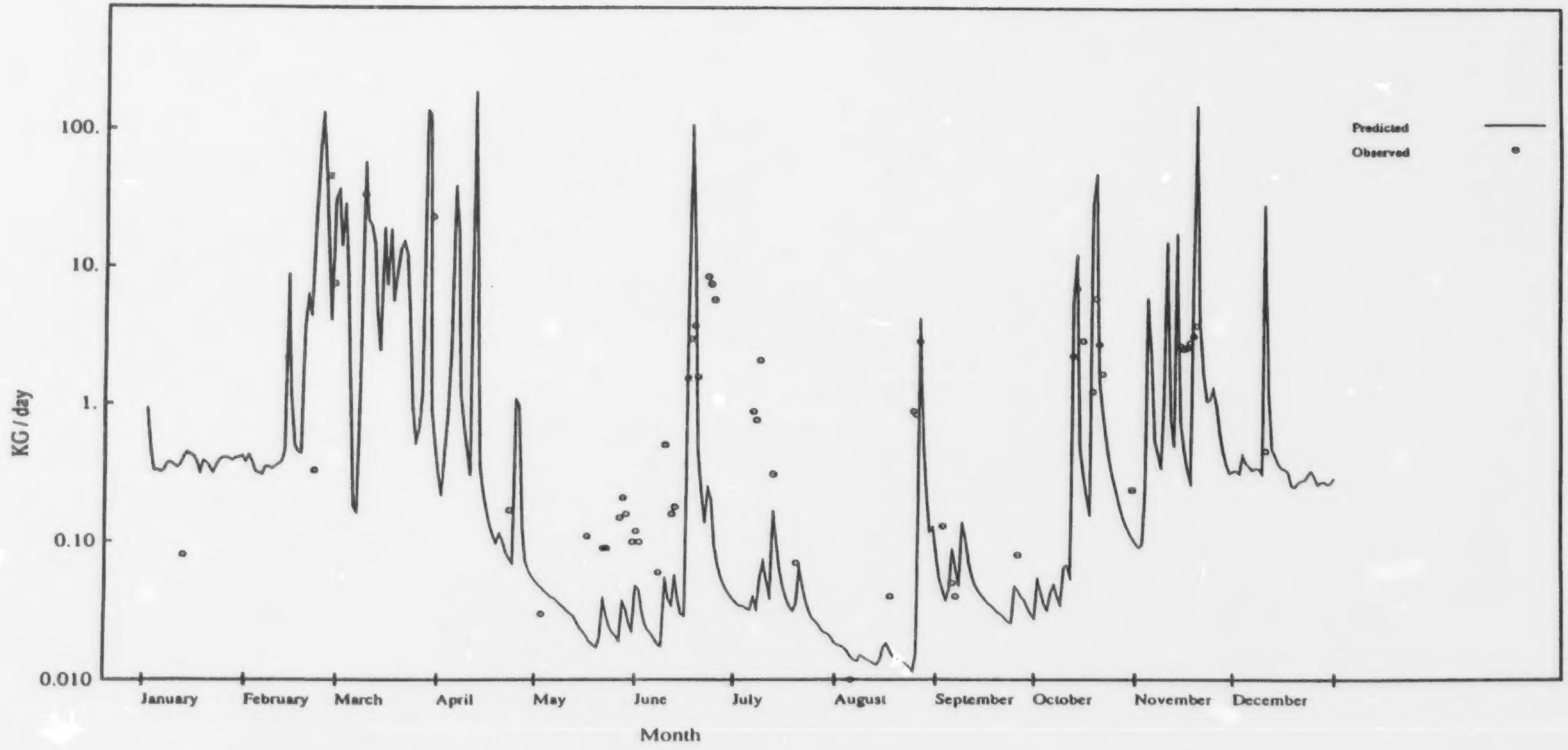


Figure 5.20 Stn. N3 Predicted and Observed Total Daily Phosphorus Load, 1985

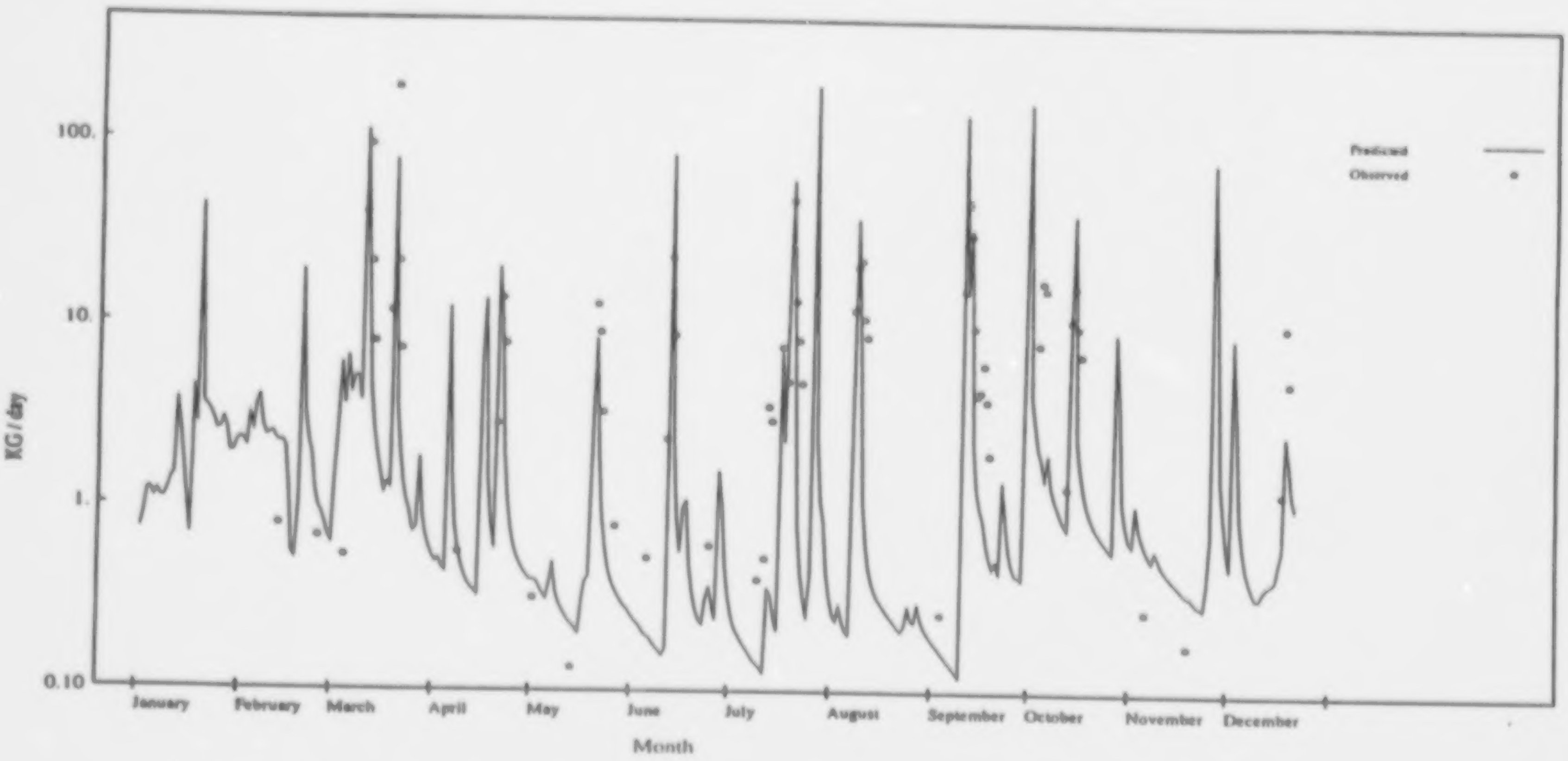


Figure 5.21 Stn. N1 Predicted and Observed Total Daily Phosphorus Load, 1986

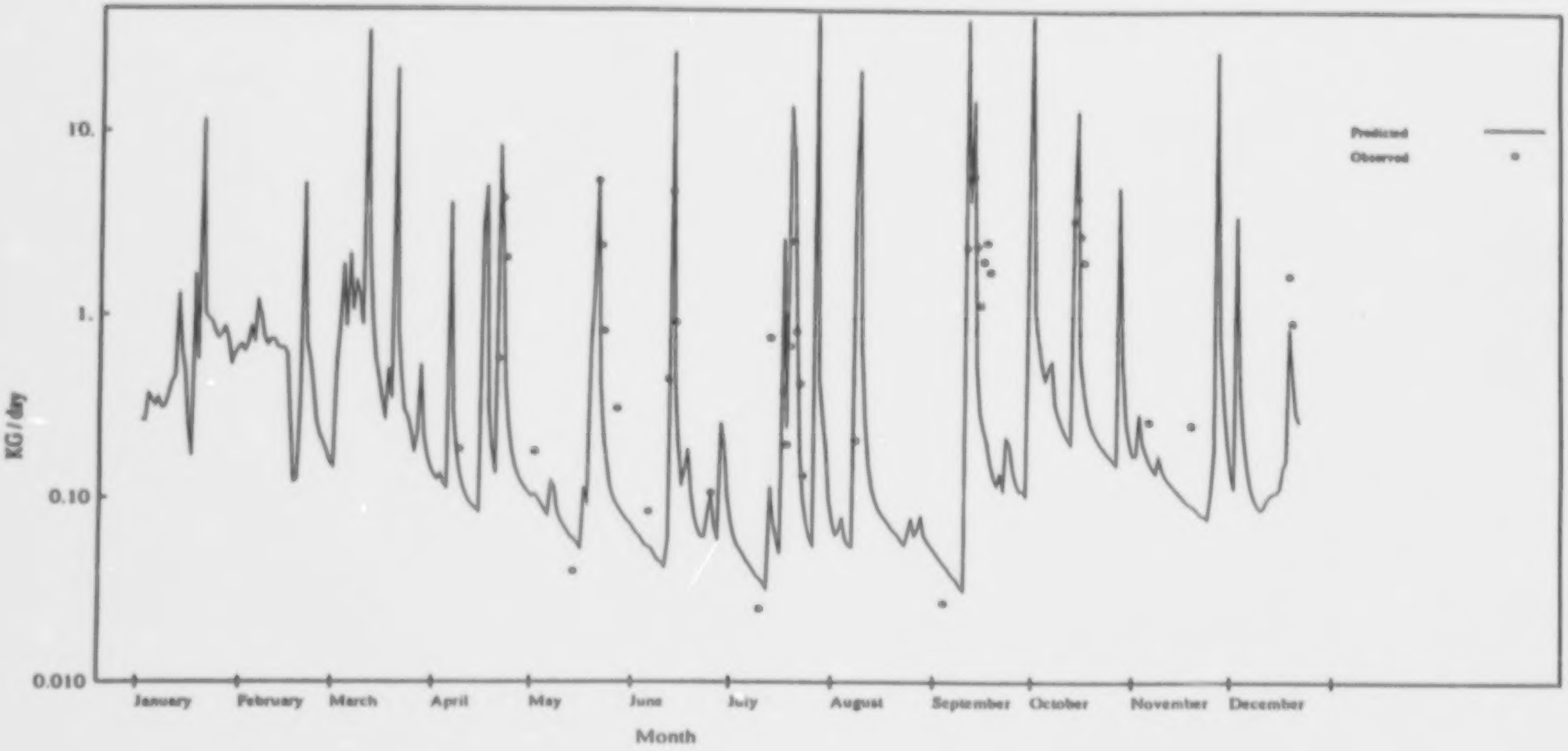


Figure 5.22 Stn. N2 Predicted and Observed Total Daily Phosphorus Load, 1986

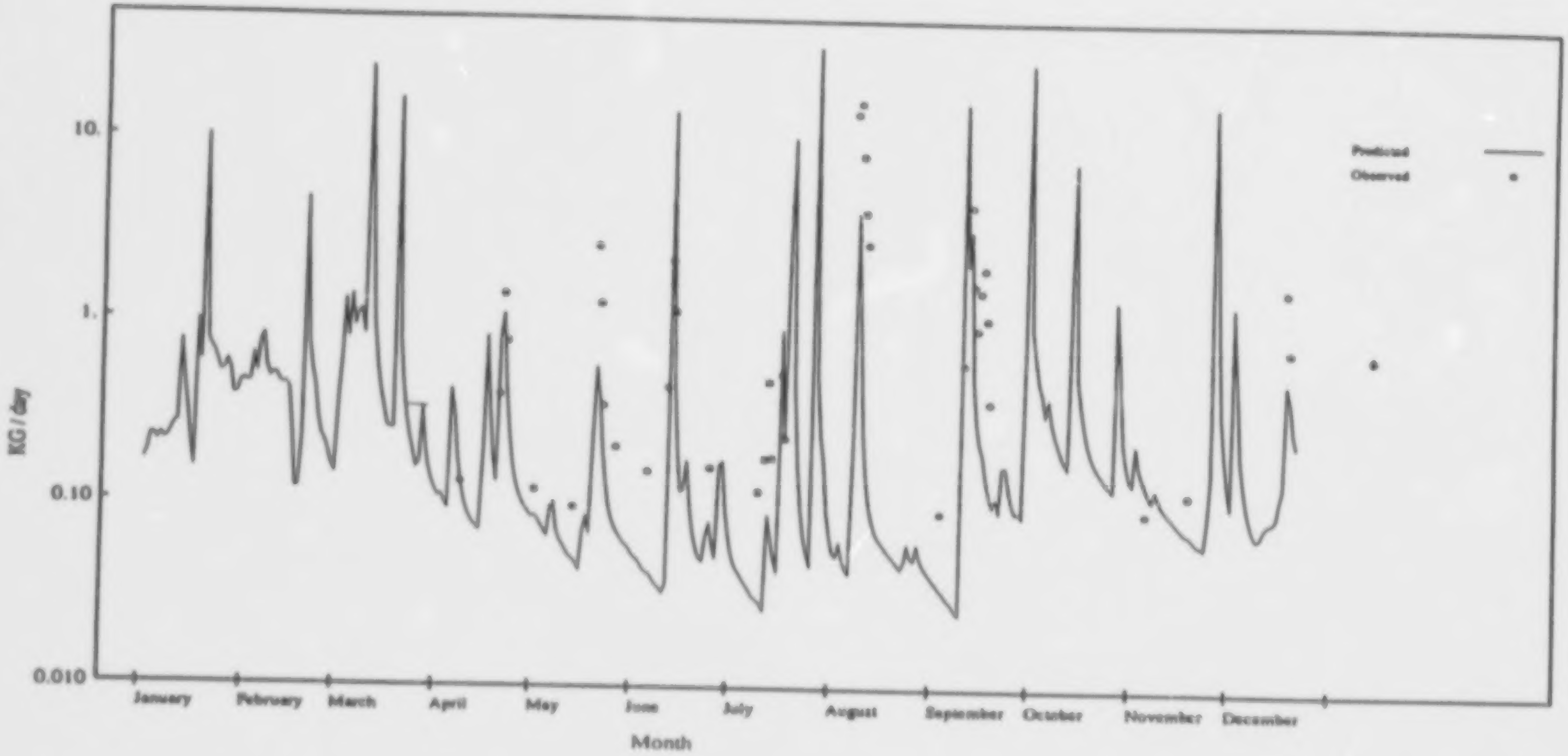


Figure 5.23 Stn. N3 Predicted and Observed Total Daily Phosphorus Load, 1986

TABLE 5.14 MONTHLY PREDICTED PHOSPHORUS LOADS

Year	Month	Total Phosphorus Load (kg)
1985	January	68.8
	February	1,894
	March	2,591
	April	1,219
	May	4.51
	June	710
	July	17.9
	August	96.5
	September	8.12
	October	449
	November	1,041
	December	184
1985 Total		8,284
1986	January	104
	February	69.1
	March	274
	April	72.1
	May	22.5
	June	88.2
	July	275
	August	54.5
	September	329
	October	92.9
	November	105
	December[1]	24.2
1986 Total		1,511

[1] Until December 21 only

TABLE 5.15 CALIBRATED HSPF PARAMETER VALUES FOR PHOSPHOROUS MODULES

Module	Group	Parameter	Explanation	Calibrated Value
PERLND	PHOS	SKPLP[1,2]	Plant uptake rates in surface soil layers	0-1.5/day
		UKPLP[1,2]	Plant uptake rates in upper soil layers	0-90/day
		LKPLP[1,2]	Plant uptake rates in lower soil layers	0-10/day
		AKPLP[1,2]	Plant uptake rates in groundwater soil layers	0-0.1/day
		X	Freundlich Isotherm parameter for four soil layers	300-1,100 mg/l
		K	Freundlich Isotherm parameter for four soil layers	700-2,200
		N	Freundlich Isotherm parameter for four soil layers	3.0
		KIMP[3]	Phosphate immobilization rate constant for soil layers	.01-.02
		KMP[3]	Phosphorous mineralization rate constant for soil layers	.003-.01

[1] Varies by PLS

[2] Varies by month

[3] Varies by soil layer

5.6.5 Atrazine Loss

The results of atrazine modelling appear in Figures 5.24 through 5.29 for daily predicted and observed loads for stations N1, N2 and N3. Observed loadings span more than three orders of magnitude with daily loads ranging from 0.004 kg to 17.1 kg in 1985 and from .001 kg to 1.97 kg in 1986.

The calibrated results are good, generally within 10-20% of observed values. Loadings are highly variable and return to base levels a few days after an event. The rate of return to base levels is not as rapid as with soil and phosphorus because a larger portion of atrazine transport is via sub-surface routes in a soluble form.

Table 5.16 summarizes monthly watershed loadings of atrazine for the study period and the estimated % of atrazine applied which is lost in each year. In both years the major runoff occurred in June. There was also substantial runoff during the snowmelt runoff period in early 1985 and in November of that year. In both years the atrazine loss is relatively low at 3.3% and 0.84% of that applied. Of course this factor is influenced by residual atrazine carried over from previous years. The majority of atrazine is applied in a pre-emergent spray in April-May and/or a post-emergent spray in May-June. A discussion of these results is presented in the next section.

Table 5.17 lists HSPF calibrated values for the sensitive atrazine parameters as discussed in Table 5.27. The Addendum contains a listing of the relevant UCI. This should be referenced for details on parameters which vary monthly or by PLS.

5.7 Discussion

5.7.1 General

The monitoring program undertaken in this study did not provide continuous records of Nissouri Creek water quality, nor did it allow for an in-depth examination of all hydrologic pathways in the system. Rather, the approach taken allowed for the calibration of HSPF within a reasonable level of confidence. Given this level of predictive confidence and the comprehensive nature of HSPF in terms of hydrology and water quality processes, we can make inference about actual watershed processes and

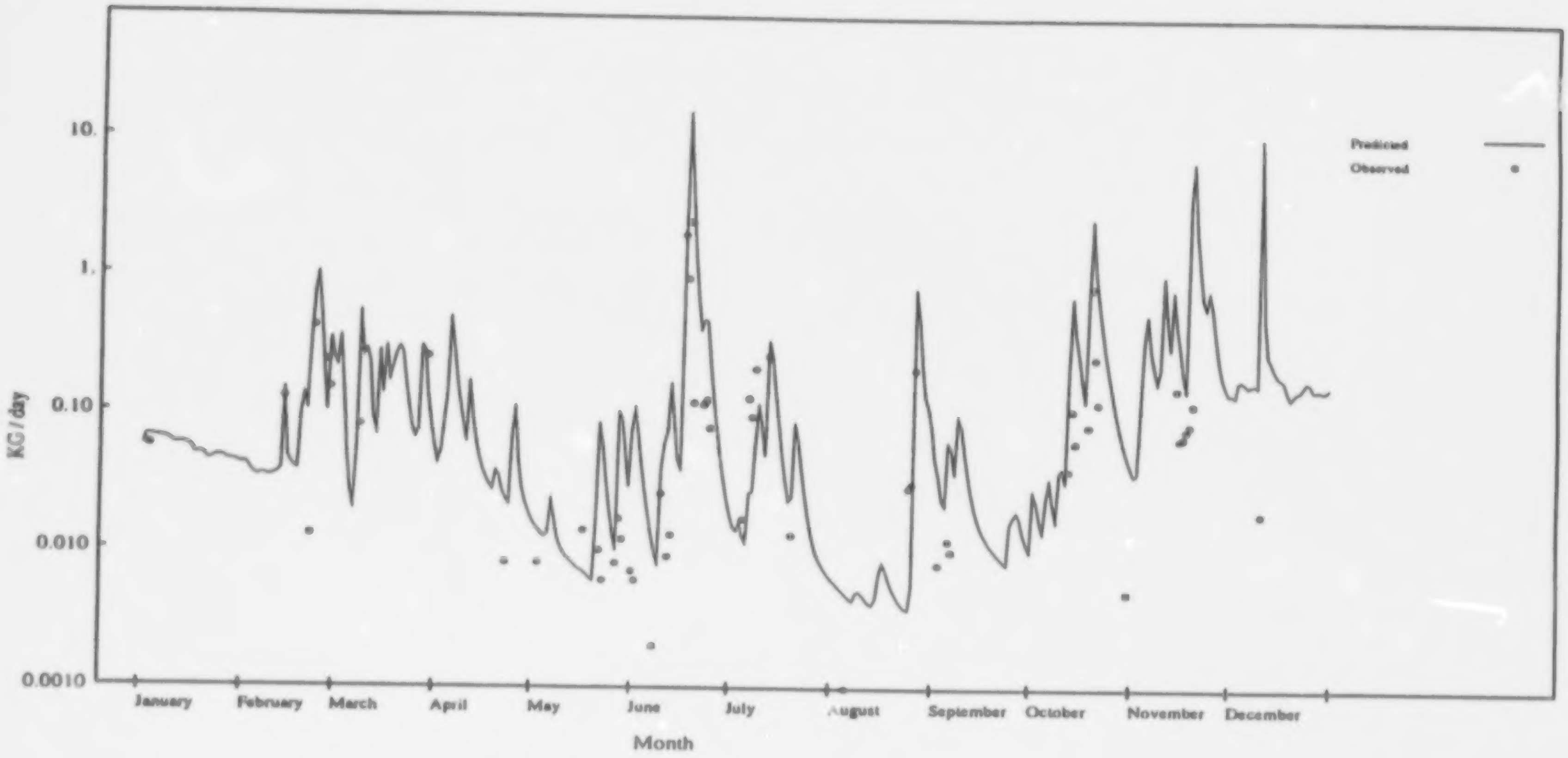


Figure 5.24 Stn. N1 Predicted and Observed Total Daily Atrazine Load, 1985

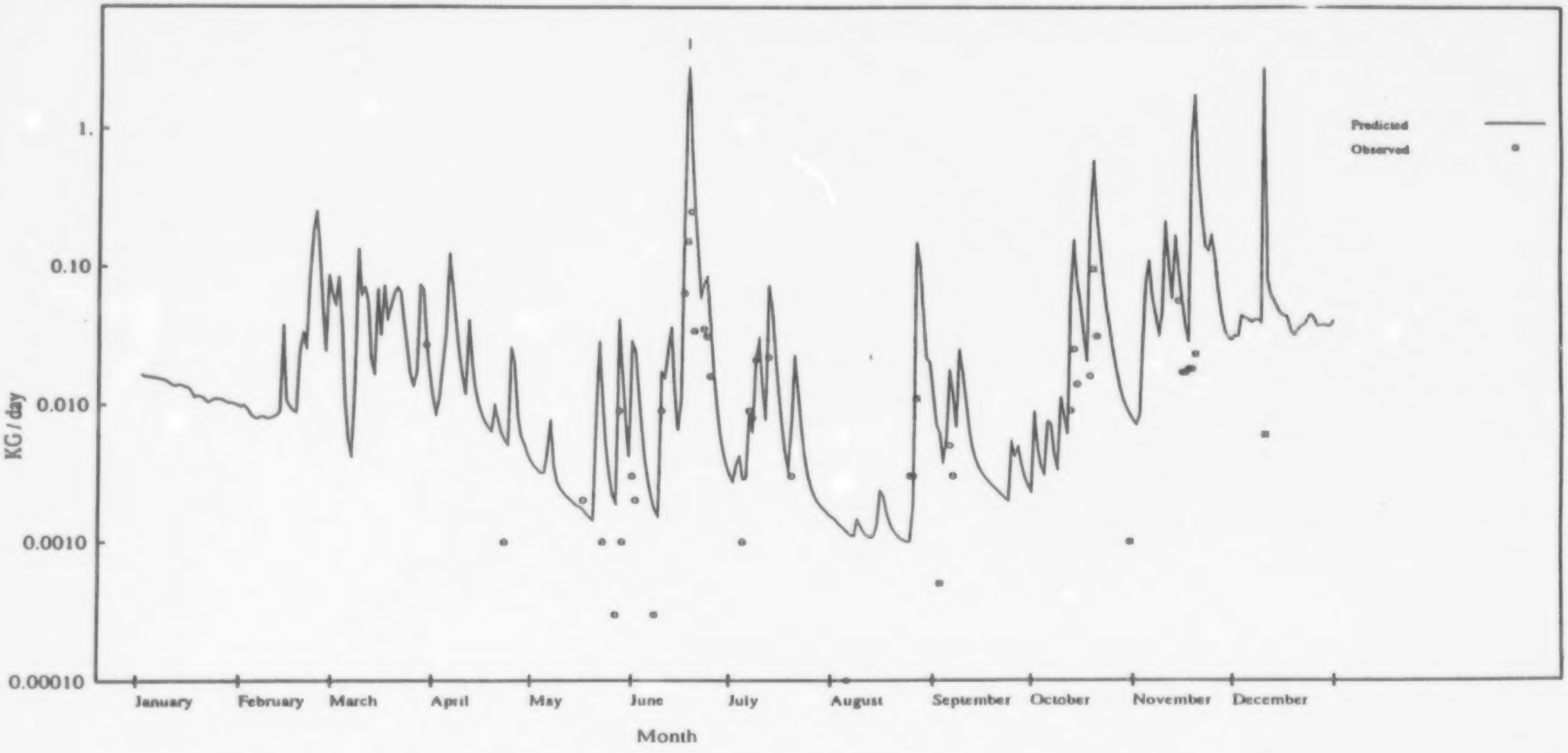


Figure 5.25 Stn. N2 Predicted and Observed Total Daily Atrazine Load, 1985

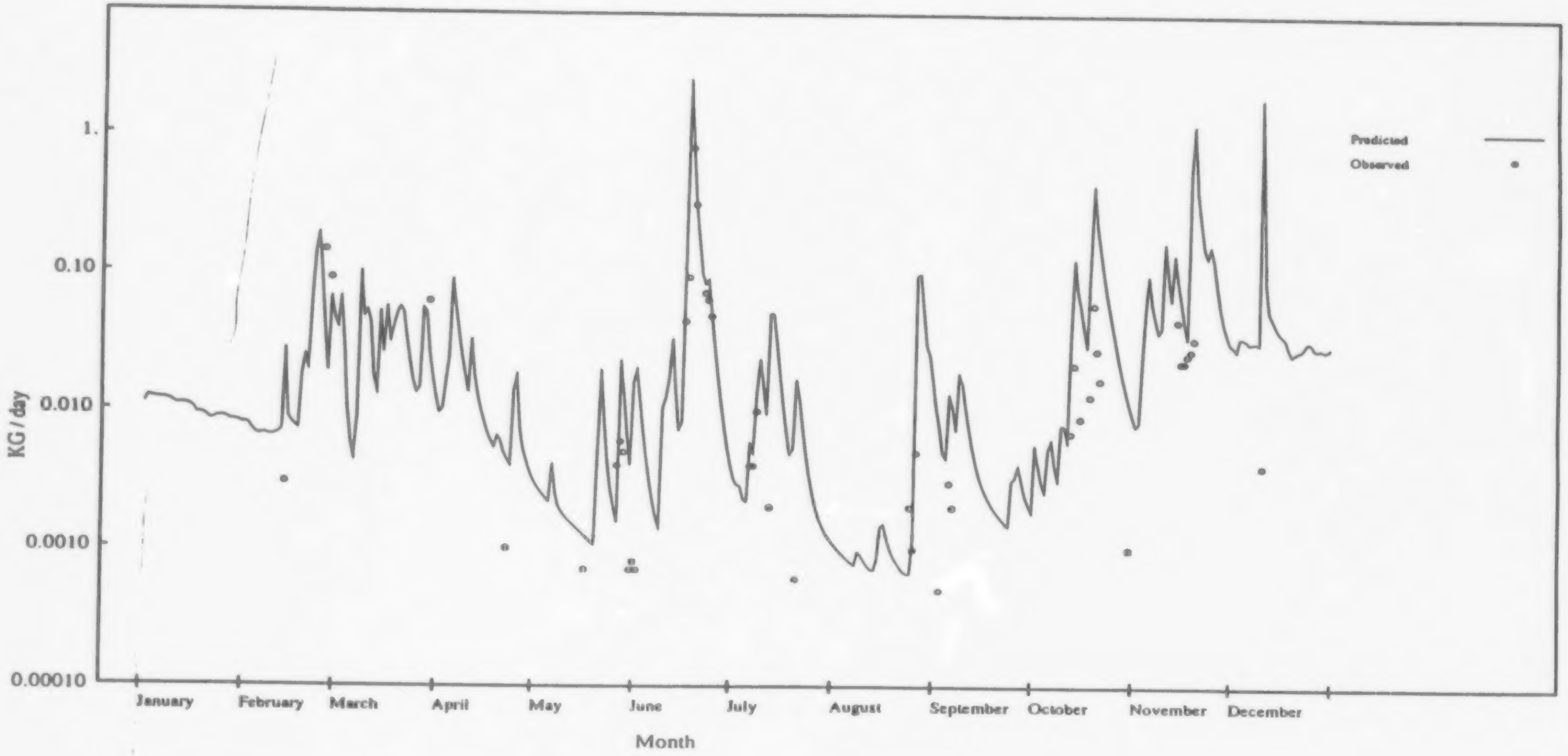


Figure 5.26 Stn. N3 Predicted and Observed Total Daily Atrazine Load, 1985

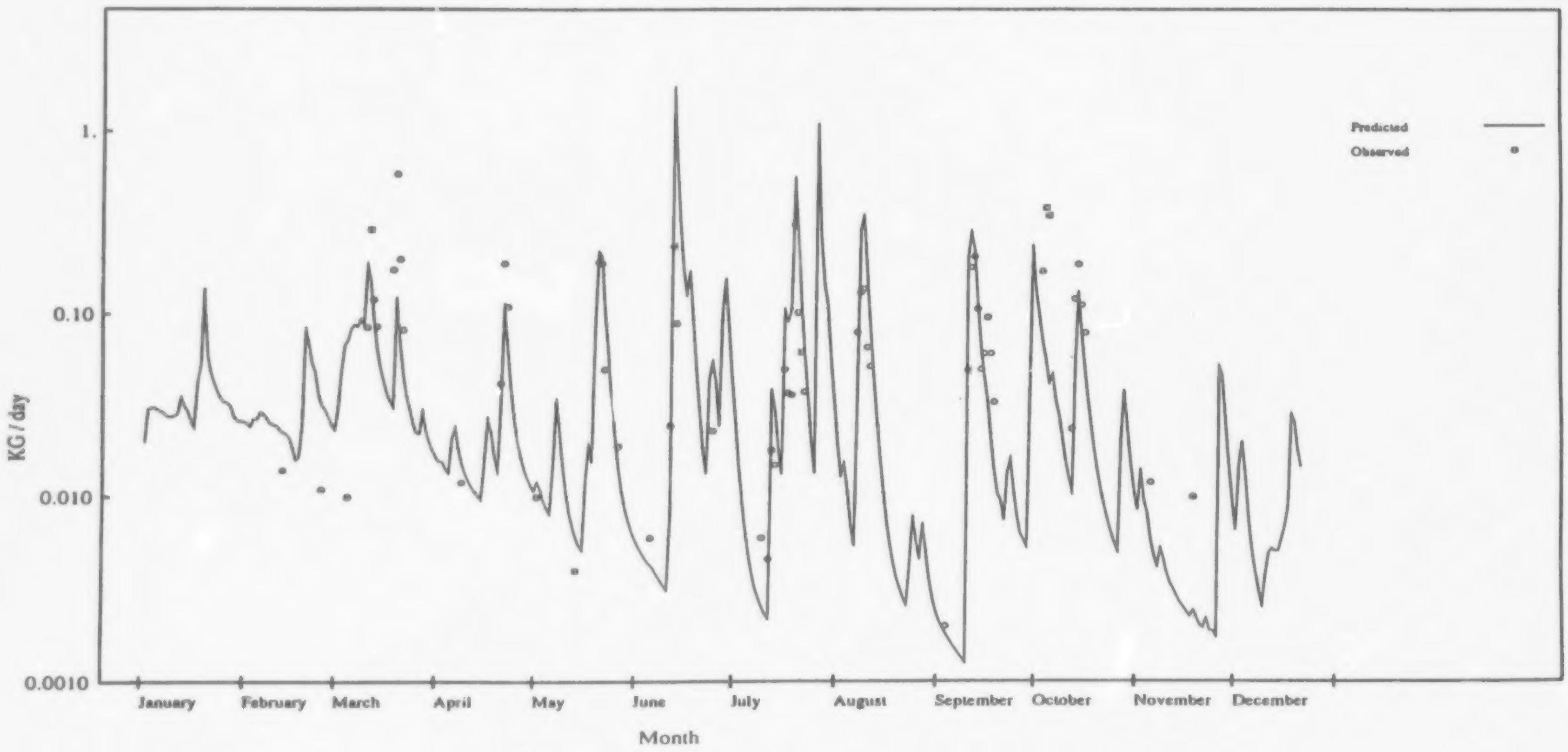


Figure 5.27 Stn. N1 Predicted and Observed Total Daily Atrazine Load, 1986

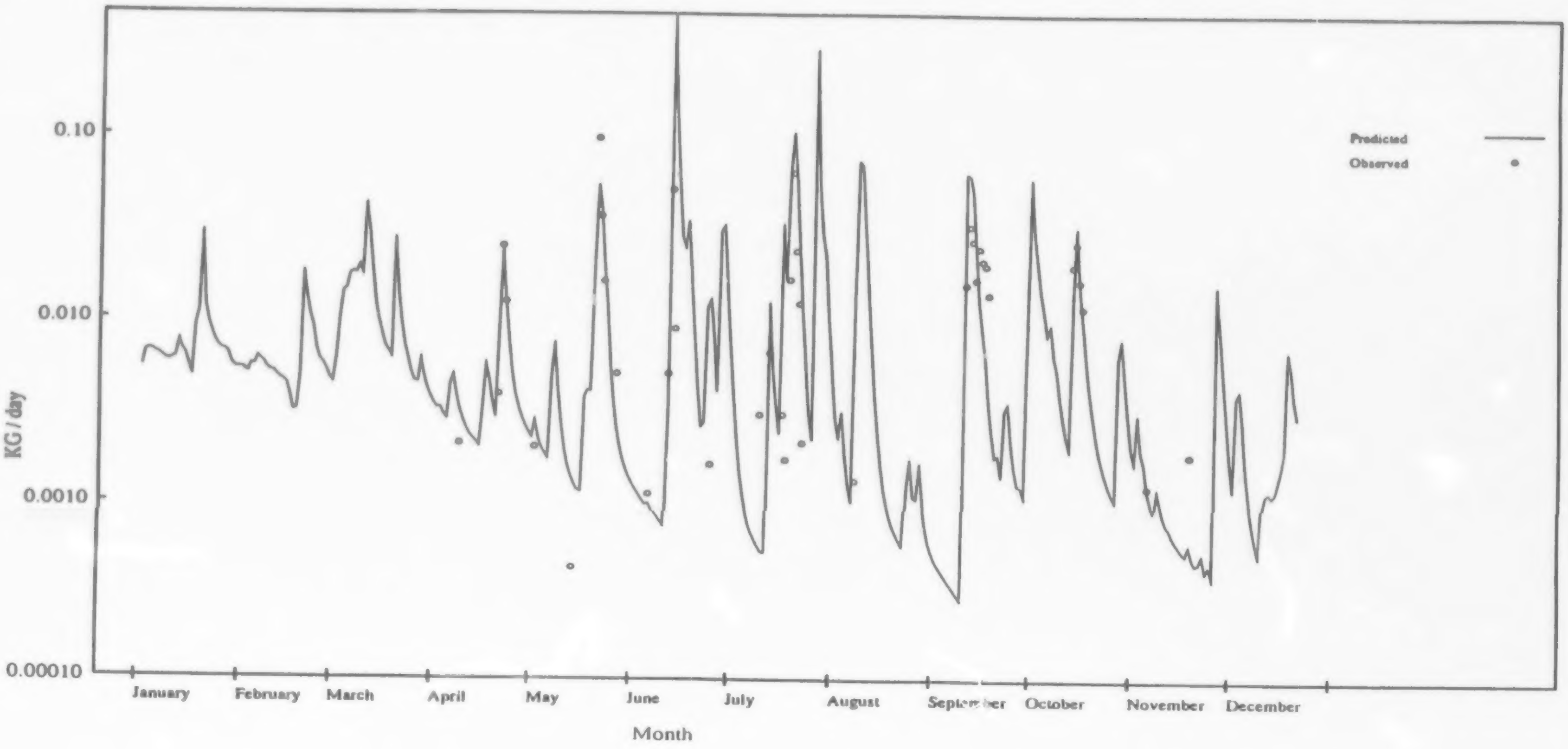


Figure 5.28 Stn. N2 Predicted and Observed Total Daily Atrazine Load, 1986

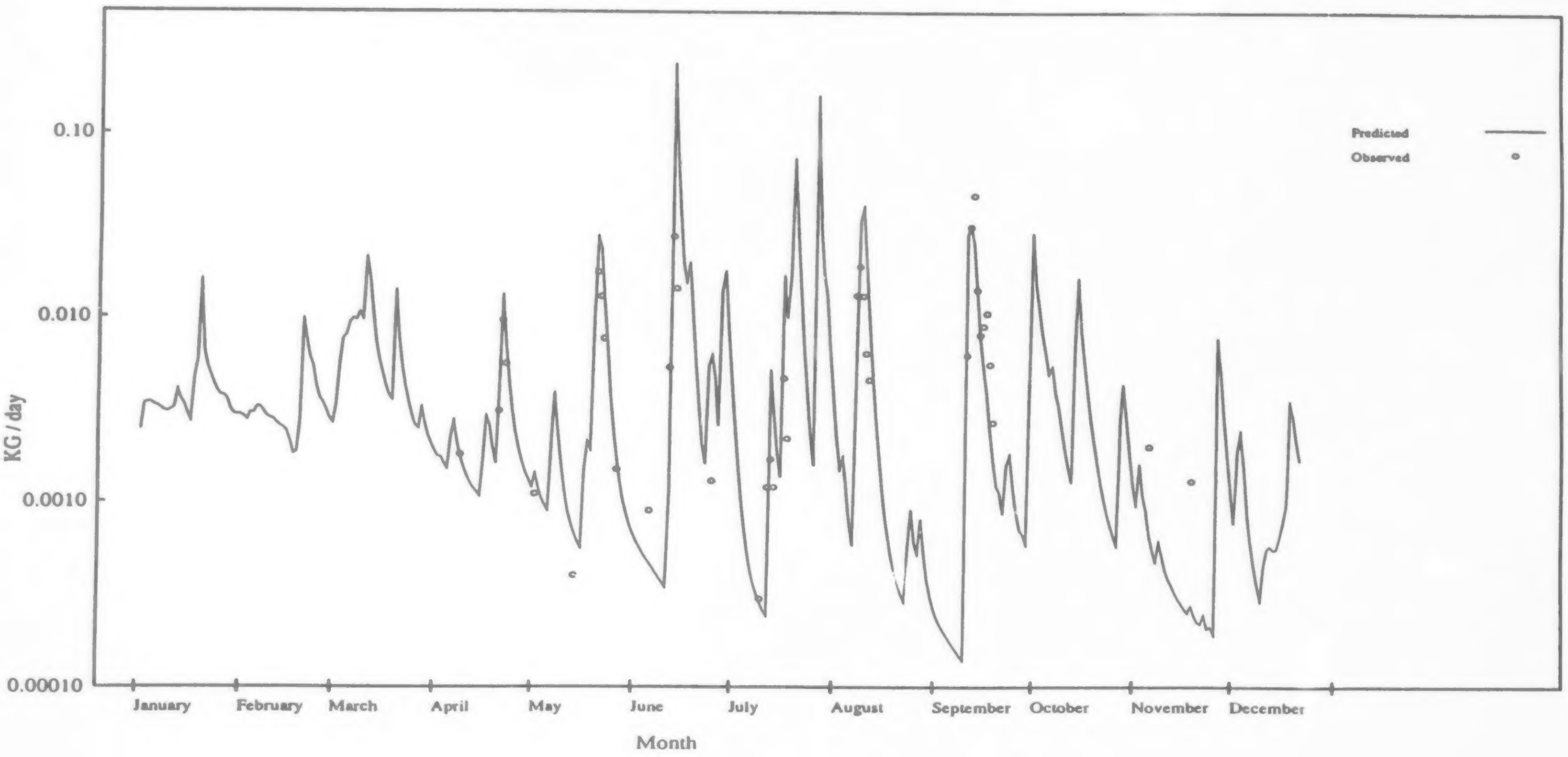


Figure 5.29 Stn. N3 Predicted and Observed Total Daily Atrazine Load, 1986

TABLE 5.16 MONTHY PREDICTED ATRAZINE LOADS

Year	Month	Atrazine Load (kg)
1985	January	1.66
	February	4.64
	March	5.65
	April	2.50
	May	0.892
	June	27.3
	July	1.70
	August	2.06
	September	0.789
	October	8.93
	November	23.5
	December	16.2
1985 Total		95.7
Total Applied		2,859
% Runoff		3.3
1986	January	1.12
	February	0.859
	March	1.84
	April	0.667
	May	1.02
	June	4.07
	July	3.32
	August	1.16
	September	1.42
	October	1.11
	November	0.253
	December[1]	0.212
1986 Total		17.1
Total Applied		2,046
% Runoff		0.84

[1] To December 21 only

TABLE 5.17 CALIBRATED HSPF PARAMETER VALUES FOR ATRAZINE MODULE

Module	Group	Parameter	Explanation	Calibrated Value
PERLND	PEST	SDGCON	Pesticide degradation rate for surface soil	.001-.015/d
		UDGCON	Pesticide degradation rate for surface soil	.001-.015/d
		LDGCON	Pesticide degradation rate for surface soil	.003-.007/d
		ADGCON	Pesticide degradation rate for surface soil	.005-.007/d
		X	Freundlich Isotherm parameter for four soil layers	0.0 mg/l
		K	Freundlich Isotherm parameter for four soil layers	3.0-12.0
		N	Freundlich Isotherm parameter for four soil layers	1.0-1.5

the mass flux and rates of material movement for the study period. This section provides a review of some of the model results in general terms as an aid to understanding the motivating factors behind erosion and agricultural chemical movement.

5.7.2 Hydrology

Table 5.18 summarizes predicted watershed outflow via surface overland runoff, interflow, and groundwater flow along with total precipitation input and evapotranspiration outflow for two study years. Total runoff differed considerably as the 1985 volume exceeded the 1986 volume by about 10 x 10^6 m^3. This difference is largely due to higher observed precipitation and lower evapotranspiration in 1985. About 7.5 x 10^6 m^3 more water entered the watershed by precipitation in that year while estimated evapotranspiration was lower by 1.5 x 10^6 m^3. There was also more snow cover on the ground carried over from 1984 at the beginning of 1985 than in 1986. As a result of these differences in the water balance, a major difference in the hydrologic pathway fluxes resulted. Surface runoff in 1985 was predicted to be more than eleven times greater than in 1986. A smaller decrease in interflow from 1985 to 1986 was predicted and groundwater flows were very similar in both years.

Table 5.10 shows that the bulk of the total runoff measured and predicted for 1985 occurred in the January to April and September to December periods. The 1986 runoff was similar in the September to December period but was much less in the winter and early spring months. Model results indicate that this discrepancy is almost entirely accounted for by surface overload runoff as a result of heavier snowfall and snowmelt in early 1985.

Table 5.19 provides a summary of total watershed outflow, precipitation and yield by season for the two full study years. It is clear that the majority of total runoff occurred in the winter and autumn periods in both years. While precipitation was relatively low by proportion during these periods, (with the exception of autumn, 1985) low evapotranspiration during the colder months and snow cover carried over from 1984 contribute to high runoff and very high yields. Winter yields exceed 100% due to high soil water levels and snow cover carried over from the previous season as well as some likely undercatch in precipitation gauges which results in an underestimate of winter precipitation estimates.

TABLE 5.1 PREDICTED WATERSHED SURFACE AND SUBSURFACE RUNOFF

	1985	1986*
Total Predicted Runoff ($m^3 \times 10^6$)	22.2	12.2
Total Surface Runoff ($m^3 \times 10^6$)	8.38	0.75
Total Interflow Runoff ($m^3 \times 10^6$)	8.58	5.52
Total Groundwater Runoff ($m^3 \times 10^6$)	5.22	5.93
Total Estimated Precipitation ($m^3 \times 10^6$)	37.3	29.8
Total Predicted Evapotransporation ($m^3 \times 10^6$)	15.1	17.6

*To December 21

TABLE 5.19:

SEASONAL SUMMARY OF PREDICTED WATERSHED OUTFLOW AND STREAM LOADINGS OF SEDIMENT, TOTAL PHOSPHORUS AND ATRAZINE FOR 1985-86

		Total Precipitation					Sediment		Total Phosphorus		Atrazine		
Seasonal Period		(mm)	% of Total Annual	Streamflow (m^3)	% of Total Annual	Yield[1] (%)	(tonnes)	% of Total Annual	(tonnes)	% of Total Annual	(kg)	% of Total Annual	% of Available
Winter (Jan.-March)	1985	259	22.0	11.8	48.2	147	855	41	4.55	55	11.9	13	0.16
	1986	90	9.6	5.2	42.6	187	57	11	0.45	30	3.8	22	0.05
Spring (Apr.-June)	1985	207	17.6	3.3	13.5	52	627	30	1.93	23	30.6	32	0.18
	1986	231	24.6	1.9	15.6	27	92	18	0.18	12	5.8	34	0.04
Summer (July-Sept.)	1985	253	21.5	0.8	3.3	10	62	3	0.12	2	4.6	5	0.03
	1986	432	46.0	2.0	16.4	15	282	54	0.66	44	5.9	35	0.04
Autumn (Oct.-Dec.)	1985	459	39.0	6.3	25.7	44	531	26	1.67	20	48.5	51	0.41
	1986	187	19.9	3.2	26.2	55	110	21	0.22	15	1.6	9	0.02

[1] Yield is calculated as (total streamflow/total precipitation volume) x 100

[2] To December 21, 1986

Spring and summer outflow and yields in both years decrease dramatically from those in the colder months due to high evapotranspiration. Note that periods of abnormally high precipitation including the autumn of 1985 and the late summer of 1986 have higher streamflow and yields.

Table 5.20 summarizes predicted surface overland runoff for the whole watershed along with precipitation inputs for snowmelt periods and extreme meteorological events. In this table, the most intensive snowmelt periods of 1985 and 1986 are lumped as one entry along with the major warm weather storms of 1985 and 1986. Only eight storms are considered to be major in this summary with six occurring in 1985 and only two occurring in 1986. These storms resulted in 11 to 120 mm of rainfall and significant surface runoff. Smaller storms in this group occurred at times when soil moisture levels were already high. It is interesting to note that only 9.1% of the total period precipitation fell during the snowmelt periods, but because of the contribution of existing snow and ice about 82% of all surface runoff occurred during this period which totalled only 57 days. Similarly, while only 15.3% of the total period precipitation fell during the six major events of 1985, these periods account for most of the remaining surface overload runoff. The two remaining major precipitation events of 1986 account for only a small amount of the surface overland runoff.

The other periods, which include more than 69% of all measured precipitation account for only 4.5% of the surface runoff. While the many smaller rainfall and snowmelt events maintain the baseflow in the sytsem, it is clear that volume and frequency of surface overland runoff is highly dependent upon the rare event of extreme proportions. The importance of surface overland runoff in determining soil, phosphorus and atrazine movement is discussed below.

No correlation between precipitation volume and surface runoff volume on an event basis is possible since antecedent conditions play a major role in determining the relative proportions of surface and sub-surface flow.

5.7.3 Soil Loss

Table 5.21 summarizes the predicted soil loss and transport to streams by land use and soil type on a unit area basis. The non-cultivated areas contributed heavy loads in both

TABLE 5.20: SUMMARY OF PREDICTED SURFACE RUNOFF AND STREAM LOADINGS OF SEDIMENT, TOTAL PHOSPHORUS AND ATRAZINE DURING SIGNIFICANT METEOROLOGICAL EVENTS FROM 1985 TO 1986

Study Period	Precipitation		Surface Runoff		Sediment		Total Phosphorus		Atrazine	
	Total (mm)	% of Total	Volume ($m^3 x10^6$)	% of Total	Mass (tonnes)	% of Total	Mass (tonnes)	% of Total	Mass (kg)	% of Total
1985 and 1986 Snowmelt	185	9.1	7.49	82.0	910	35.0	4.75	48.5	10.7	9.5
Major 1985 Storms (6 events)	311	15.3	1.19	13.0	1,031	39.7	3.35	34.2	60.9	54.0
Major 1986 Storms (2 events)	128	6.3	0.05	0.5	139	5.3	0.40	4.1	2.5	2.2
Other Periods (non-significant)	1,413	69.4	0.40	4.5	519	20.0	1.30	13.2	38.7	34.3

TABLE 5.21 PREDICTED UNIT AREA SOIL WASHOFF BY LAND USE AND SOIL TYPE

Land Use	1985 Washoff (t/h)	1986 Washoff (t/h)
Corn	0.50	0.11
Mixed Grain	0.53	0.14
Non-cultivated	0.44	0.39
Soil Type		
Sandy loam	0.59	0.12
Medium silt loam	0.50	0.11
Fine silt loam	0.78	0.17
Organic	0.38	0.44
Watershed Average	0.51	0.17

Whole Watershed PLUARG (1976) Estimate: 0.35 t/h years as did the organic soils. This is due to the fact that the non-cultivated land and high organic soils tend to be near the stream in areas with high topographic relief. These areas therefore have much higher delivery ratios and are subject to more rill and gully erosion than the flatter areas which are further from the watercourse. The corn and mixed grain land uses contributed similar soil loadings in both years. Mixed grains contributed marginally more soil because of the lower canopy cover typical for these crops.

Fine particle soils were predicted to contribute significantly more soil to the watercourse than the sandy soils as expected because of their higher erodability and tendency to remain in suspension in overland flow.

The results of this study are very similar to the PLUARG estimates (PLUARG, 1976) when 1985 and 1986 are averaged. Clearly, annual variability in soil erosion is very high.

Table 5.19 summarizes predicted seasonal stream loadings of sediment and the percentage of annual loads by season. The winter, spring and autumn of 1985 contributed the majority of the total period sediment loading with the largest load occurring in the spring of 1985 along with the high streamflows of that period. Summertime loadings tend to be much lower as crop canopies protect the soil and plant stalks inhibit soil delivery to the streams. The highest percentage of sediment loadings for 1986 occurred in the summer months but the total load was much less than winter, spring and autumn loadings predicted for 1985.

Frozen ground and snow cover in the winter months tends to modify the soil loss considerably when soil losses by season are compared to streamflow for the same periods. This is especially apparent when the soil loss and streamflows for the winter of 1986 are compared to those for the autumn of 1985. Streamflows are similar in these cases yet soil loss differs by an order of magnitude. Autumn is a transition period during which crop cover is reduced with a concomitant increase in soil erosion potential.

Table 5.20 summarizes predicted sediment loadings during snowmelt periods and during the major storms of 1985 and 1986. The relationships between erosion/soil delivery and surface overland runoff is clear. About 35% of the total period soil delivery occurs during the snowmelt periods when 82% of the surface overland runoff occurs. Obviously, snow and ice cover and the frozen state of the soil modify the soil loss to some extent. The soil losses during the six significant 1985 warm weather storms is also very high. During these events which result in only 13% of the surface runoff, almost 40% of the total period sediment loadings occur. In fact, hundreds of tonnes of material were transported out of the watershed in single events especially during early spring and late fall when crop cover was low.

The two major events of 1986 were proportionally smaller and resulted in considerably less soil delivery than the 1985 events. About 80% of all sediment loading to the watercourse occurred during the relatively short snowmelt periods and eight major events over the two year period during which only about 31% of all measured precipitation occurred.

As discussed earlier, antecedent conditions greatly affect the incidence of surface overland runoff and therefore, a simple correlation between sediment loadings caused by runoff and rainfall and precipitation volume and intensity is not possible.

5.7.4 Total Phosphorus Loss

Table 5.22 lists predicted total phosphorus loadings to the watercourse as well as loadings of sediment-associated, surface phosphate and sub-surface phosphate for both full study years. The ratio of sediment-phosphorus to the total phosphorus load is also listed.

Total phosphorus loadings decrease by a factor of five from 1985 to 1986. This reduction is especially apparent in terms of sediment associated phosphorus and surface phosphate runoff. The reduction in sediment associated phosphorus is similar in proportion to the reduction in soil loss predicted from 1985 to 1986. The reduction is consistent and understandable since sediment associated phosphorus is totally dependent upon soil transport and delivery.

Phosphorus loadings predicted in this study are similar in 1985 to those estimated in the PLUARG study (see Table 3.6). An average of about 4.9 tonnes of phosphorus were predicted to be lost in this study. The PLUARG studies reported that about 4.6 tonnes was lost annually from 1975 to 1977.

TABLE 5.22 PREDICTED WATERSHED PHOSPHOROUS PATHWAYS

	1985	1986
Total Phosphorus Load (kg)	8,284	1,511
Sediment-Associated Load (kg)	4,881	902
Surface Phosphate Runoff (kg)	3,000	291
Interflow Phosphate Runoff (kg)	290	191
Groundwater Phosphate Runoff (kg)	113	127
Sediment P/Total P	0.59	0.60

PLUARG Total Phosphorus Load Estimate (1976) using Beale Estimator (kg): 4,600

The surface phosphate reduction is proportionally more pronounced, decreasing by a factor of about ten from 1985 to 1986. This reduction is consistent with the proportional decrease in surface overland runoff from 1985 to 1986 of about eleven times.

The reduction in sediment associated phosphorus and surface phosphate runoff can therefore be explained in terms of the predicted reduction in soil loss and surface overland runoff. The effects of agricultural fertilizer application and some organic phosphorus (plant residue) washoff in the overall mass balance are relatively minor and tend to only cause marginal modifications to the total phosphorus delivery.

Predicted sub-surface phosphorus delivery accounts for about 5% and 21% of the total loadings in 1985 and 1986 respectively. The total mass of this component remained relatively constant from 1985 to 1986 at 318 to 403 kg. Higher loadings of sub-surface phosphate in 1985 were due to higher total interflow (see Table 5.18).

Table 5.19 summarizes the predicted total phosphorus loadings to the watercourse by season for both study years. In addition to the soil attached form phosphorus has sub-surface and surface soluble components which tend to modify the seasonal trends although phosphorus transport is also highly related to surface overland runoff. A higher proportion of phosphorus is predicted to move into the streams during the snowmelt period than sediment because of the additional phosphorus component caused by overland flow leaching phosphorus from surface soils. The ratio of total phosphorus to soil at the watershed outlet averages 6.6 gm/kg in the winter months decreasing to 2.4 gm/kg during the other months.

Table 5.20 summarizes predicted total phosphorus loadings to streams during snowmelt periods in 1985 and 1986 and during the major warm weather storm events. This summary confirms the observation from Table 5.19 regarding the relatively higher proportion of phosphorus than soil which washes off during snowmelt periods as almost half of the total phosphorus loading occurred during snowmelt. As was the case with sediment loadings, a large portion of the total phosphorus loading occurred during the eight most significant storms and relatively little loading occurred during the other times.

5.7.5 Atrazine Loss

Table 5.23 summarizes the predicted pathways of atrazine in terms of the total stream loading, sediment associated loading, surface soluble loadings, interflow loading and groundwater loading for 1985 and 1986. It is clear from this table that the majority of atrazine (99%) moves in the soluble form due to its relatively high solubility in water and low affinity for soils. The reduction of atrazine loadings from 1985 to 1986 are consistent with those predicted for phosphorus loadings with a reduction by a factor of about five. As noted in Table 4.16 there was a significant reduction in the amount of atrazine applied from 1985 to 1986 by about 40% which accounts for a portion of the decrease. Atrazine runoff predicted in this study was similar in 1986 to that estimated during the PLUARG study period. Total atrazine application rates were higher in this study with 2,859 and 2,046 kg applied in 1985 and 1986 respectively (see Table 5.16) and about 2,050 kg applied annually from 1975 to 1977 (see Table 3.7).

Table 5.19 summarizes the predicted watershed loadings of atrazine by season along with the percentage of available atrazine which was lost to the watercourse. The snowmelt period of 1985 was an active atrazine transport period due to the extremely high surface overland runoff. Overland runoff would result in the solubilization of the residual atrazine in the surface soils from the previous year. Most of the atrazine is applied in the spring period. This period is predicted to be an active transport period accounting for about one third of the total annual losses. The high surface overland runoff predicted in the summer of 1986 and autumn of 1985 (some atrazine is applied in the autumn for overwinter weed control) were also very active atrazine loss periods. In terms of the percentage of available atrazine which was lost to the watercourse, the summer periods are very low.

The PLUARG study estimated that the January to April period was the most active atrazine movement period although the May to August period contributed significantly as well (see Table 3.8). In that study, the most active periods were in February and March of 1976 and March of 1977. These were likely snowmelt periods. Other months of active movement were in June of 1975 and July of 1976 following the application periods (see Table 3.9).

TABLE 5.23 PREDICTED WATERSHED ATRAZINE LOAD PATHWAYS

	1985	1986
Total Atrazine Load (kg)	95.7	17.1
Sediment Associated Load (kg)	1.3	0.2
Surface Soluble Atrazine Runoff (kg)	44.8	2.7
Interflow Atrazine Runoff	41.7	11.1
Groundwater Atrazine Runoff	7.9	3.1

PLUARG Atrazine and Desethyatrazine Runoff (kg) May 1975 - April 1977: 16.1

Table 5.20 summarizes the stream loadings of atrazine predicted for snowmelt and major warm weather storms in 1985 and 1986. Clearly, the 1985 storms resulted in the most washoff of atrazine while the 1986 storms and the snowmelt periods contributed relatively little.

The other periods contributed over 34% of all atrazine washoff while contributing only 20% and 13% to sediment and phosphorus washoff. This relatively larger contribution is due to the fact that atrazine is more mobile through the tile drain system. As noted in Section 4.3.3, atrazine was commonly found in the four selected tile drain outfalls. It was also observed to penetrate the soil profile to a depth of 30 cm in the field level decay studies (see Appendix A) and was found in piezometers at a depth of 2.4 metres. While soil and phosphorus loss through tile drains was predicted to be relatively small (phosphorus losses through tiles were predicted to be 5% of the total, see table 5.22), the atrazine losses by this route are significant at 44 and 65% of the total losses predicted for 1985 and 1986 respectively. Groundwater pathways for atrazine loss are also predicted to be significant accounting for 8 and 18% of the losses in 1985 and 1986 respectively. Sub-surface pathways combined are predicted to account for 57% of the total atrazine loss over both years. The PLUARG study estimated that about 31% of atrazine was transported in baseflow which includes tile flow and groundwater flow (see Table 3.10).

Atrazine, therefore, appears to behave in a similar manner to phosphorus inasmuch as it is most mobile during extreme storm events, especially during very active snowmelt and erosion periods and storms which occur shortly after application. However, atrazine decays in situ and is present at highly variable amounts throughout the year. It is not present at high levels in the soil during the winter and early spring and is therefore not as susceptible to snowmelt washoff as is phosphorus. Also, atrazine is relatively soluble and mobile in the topsoil layer. Therefore, atrazine can percolate to the depth of the tile drains (0.5 to 1.5 metres) following less significant storms and enter the watercourse in relatively larger amounts than phosphorus. Groundwater transport of atrazine is relatively small because the time required for transport from the field to the stream by groundwater is sufficiently long to allow for substantial decay and uptake by plants.

Total atrazine loss predicted in this study was relatively low at 0.8 to 3.3%. Since losses are distributed over several events it is unlikely that watercourse concentrations will rise to lethal levels at any time. The highest atrazine concentration in surface water observed in this study was 350 ug/L at station N3. The estimated 96 hour LC_{50} for rainbow trout is 4.5 mg/L (Agriculture Canada, 1982).

6.0 HSPF DEMONSTRATION

6.1 General

The overall objective of land management modelling is to assist in developing best management practice (BMP) plans for fields, farms, and regions. The initial task in modelling BMP's is to define the existing agricultural practice. The model set-up for the existing case using a calibrated model requires that process parameters and special criteria selected reflect these farming practices. In the Nissouri Creek Watershed at the time of this study conventional farming practices predominated. Cultivated fields were either continuously row cropped or were in a rotation with row crops and mixed grains. Most fields were tilled by moldboard plowing and usually one other secondary tillage operation to prepare the soil for planting. Cultivation was usually in rows parallel to field boundaries rather than to topographic contours. Fertilizer was added to the field surface in the form of manure (usually in the fall or winter) and chemical solutions or slurries near seeding time. Atrazine was used on almost all of the corn hectarage for weed control. Applications were most common in late spring after planting at a pre-emergent or post-emergent stage. Some atrazine application occurs in the fall after harvest to control weeds over winter. The bulk of the atrazine was added by surface spraying of chemical slurries and solutions.

Some plant residue is allowed to lay on the surface of fields from harvest to spring tillage. However, fall plowing was more common. Fields soils were therefore totally exposed for some period of time between plowing and crop canopy development. Crops were planted as close to drainage channels as possible (usually within a few metres) with a narrow, usually steep, grass strip along channel banks.

The calibrated version of HSPF discussed earlier reflects conventional farming practice. The timing of special operations such as fertilization, pesticide spraying, tillage operations, and planting is variable from field to field, farm to farm, and year to year depending upon weather, farmers schedules, market forces, etc.

Conventional practices generally result in uncontrolled or "worst case" erosion and chemical loss for a particular watershed. BMP's are designed to improve upon localized and general conditions which lead to erosion without significantly reducing farm productivity. A list of BMP's have been compiled by Donigian et al. (1983), from several previous reports. These practices are relevent to areas like the Nissouri Creek Watershed. A definition of each practice is included in Appendix G.

The BMP's described in Donigian's report include non-structural measures which are generally practices which affect tillage practices and farm operating procedures in an attempt to protect the soil surface, reduce surface runoff, retard soil loss, and provide more moisture storage and infiltration. Structural measures are those which necessitate construction of control and treatment equipment or structures in the watershed. These measures often focus on localized problems and sometimes require continuous maintenance. They do not generally affect farm practices or field operations. A third type of BMP is the input management option. These practices focus on improving and optimizing the use of pesticide and/or fertilizer and thereby reduce the loss of agri-chemicals by limiting their vulnerability and availability.

Donigian's report includes a list of impacts for each BMP and a discussion of how each affects the relevant HSPF parameters or special actions. The accuracy with which one can adjust model parameters to reflect proposed changes is questionable at this stage in the development of the technology. This is one of the areas of research commonly recommended by model users. The Donigian report can therefore provide only general guidelines or reasonable estimates for model adjustment.

As part of this study a set of six BMP's were selected. These include:

- no tillage or zero till,
- contour-strip cropping,
- complete tile drainage,
- retention basins,
- optimization of agri-chemical application, and
- incorporation of agri-chemicals below the soil surface.

Each of these practices was examined through two year simulations (1985 and 1986 input data sets combined) with adjusted model parameters and special conditions.

The purpose of these demonstration simulations is to perform typical assessments and demonstrate how HSPF can accommodate, and is sensitive to, a wide variety of alternative management scenarios. The accuracy of prediction for the various scenarios is dependent upon the accuracy of change made in relevant model parameters. Since very little Ontario experience has been published in this respect, the predictions should be regarded as qualitative in nature.

The predicted percentage reduction of each BMP from the base case should be treated as a "ball park estimate" of the specific scenario benefits. In some cases model parameters have been altered significantly to highlight the sensitivity of the model to a process and therefore predicted results tend to be very optimistic or "best possible". In land management planning, a more conservative approach may be warranted in which modellers consider parameter changes very carefully and in most cases a practical lower and upper confidence limit should be predicted from multiple computer runs.

As in all BMP demonstrations, a base case was run with the linked 1985 and 1986 time series input files. The 1986 land use system was used in this assessment since it involved fewer PLS's and therefore fewer computational elements. Each BMP was run for the same period and all results are presented in terms of accumulative soil, phosphorus and pesticide losses. Soil losses are not evaluated for the input management options since these practices only affect chemical movement.

In addition to BMP demonstration runs, five HSPF utility modules were used in a demonstration mode to illustrate their usefulness and the power of the data management aspects of HSPF. These modules include:

- PLTGEN for plot file generation,
- COPY to prepare and modify TSS input files,
- GENER to modify, aggregate or perform standard transformations on time series files,
- DURANL to conduct excusion and lethality analyses, and
- DISPLY to summarize and tabularize time series data.

The input/output and usefulness of these routines as well as the BMP demonstration are discussed in more detail below.

6.2 Best Management Practices

6.2.1 No Tillage

The no tillage system is one of the most common and often most effective land management practice. In this system the soil is not cultivated. Seeds are pushed into the soil with a seed drill. Crop residue is left on the surface and chemical weed control is usually required.

The most obvious benefits of imposing a no till system onto a conventional system include the following:

- plant residue protects soil from rain drop impact and resultant sheet erosion;
- plant residue increases interception capacity and therefore reduces surface runoff volume;
- plant residue increases surface roughness which in turn slows surface runoff, allows more settling of eroded material and increases total infiltration;
- reduced tillage results in less soil compaction and the maintenance of higher infiltration rates in the long term. A slight reduction in infiltration rates may occur in the short term due to the fact that conventional plowing lossens the surface soil layer and increases infiltration for a few months;
- the structure of surface soils is maintained which reduces soil erosion by overland flow, termed rill and gully erosion. There is also a slight increase in the surface soil water holding capacity; and
- more evapotranspiration occurs in the sub-surface soils as more deep rooted vegetation remains in place.

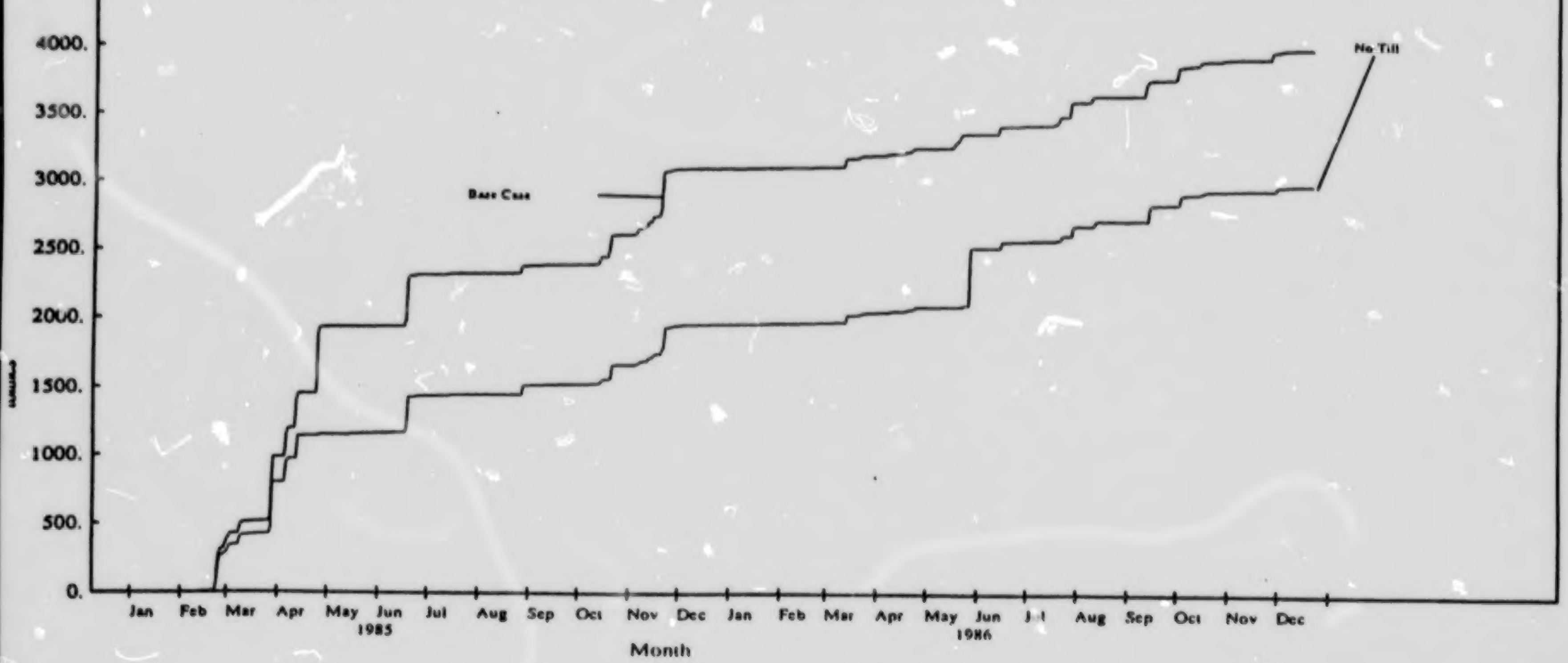
Table 6.1 lists the relevant model parameters and the changes which were used in the conventional and the no till systems.

Figures 6.1 to 6.3 display the predicted base case and no till cumulative soil, phosphorus and atrazine losses. Table 6.2 summarizes some relevant comparison data for the conventional and no till case for the whole watershed. The no till system is predicted to result in significant surface runoff and soil loss reductions (13 and 28% respectively) with a corresponding savings of sediment associated and soluble phosphorus of 25%. Atrazine

TABLE 6.1 CHANGES TO HSPF PARAMETERS FOR A NO TILL LAND MANAGEMENT SYSTEM

Parameter	Meaning	Conventional Value	No Till Value
CEPSC	Interception storage	Varies from 0.0 mm in fall and winter to maximum of from 2.0 to 5.0 depending on slope class.	Fall and winter minimum values raised to 2.0 to 2.5 and maximum values are left as is.
UZSN	Upper zone water storage capacity	15.0 to 20.0 mm in late summer.	Winter values raised to 20.0 mm and summer values set at 18.0.
NSUR	Surface roughness Parameter	Winter value of 0.15 to summer value of 0.25.	0.25 all year
INFILT	Infiltration capacity	Winter - .001 mm/h. Spring, summer & fall up to 1.0 mm/h.	Summer maximum reduced to 0.5 mm/h.
LZETP	Lower zone evapotranspiration	Winter 0.1 Summer 0.5	Winter raised to 0.15.
COVER	Proportion of land shielded by vegetation	Winter - 0.05 Summer up to 0.8	Winter raised to 0.3 to 0.4.
KSER	Soil washoff parameter	15 to 26 depending on soil.	.10 to .17 depending on soil.

Figure 6.1 Base Case and No Till Watershed Cumulative Soil Loss, 1985-86



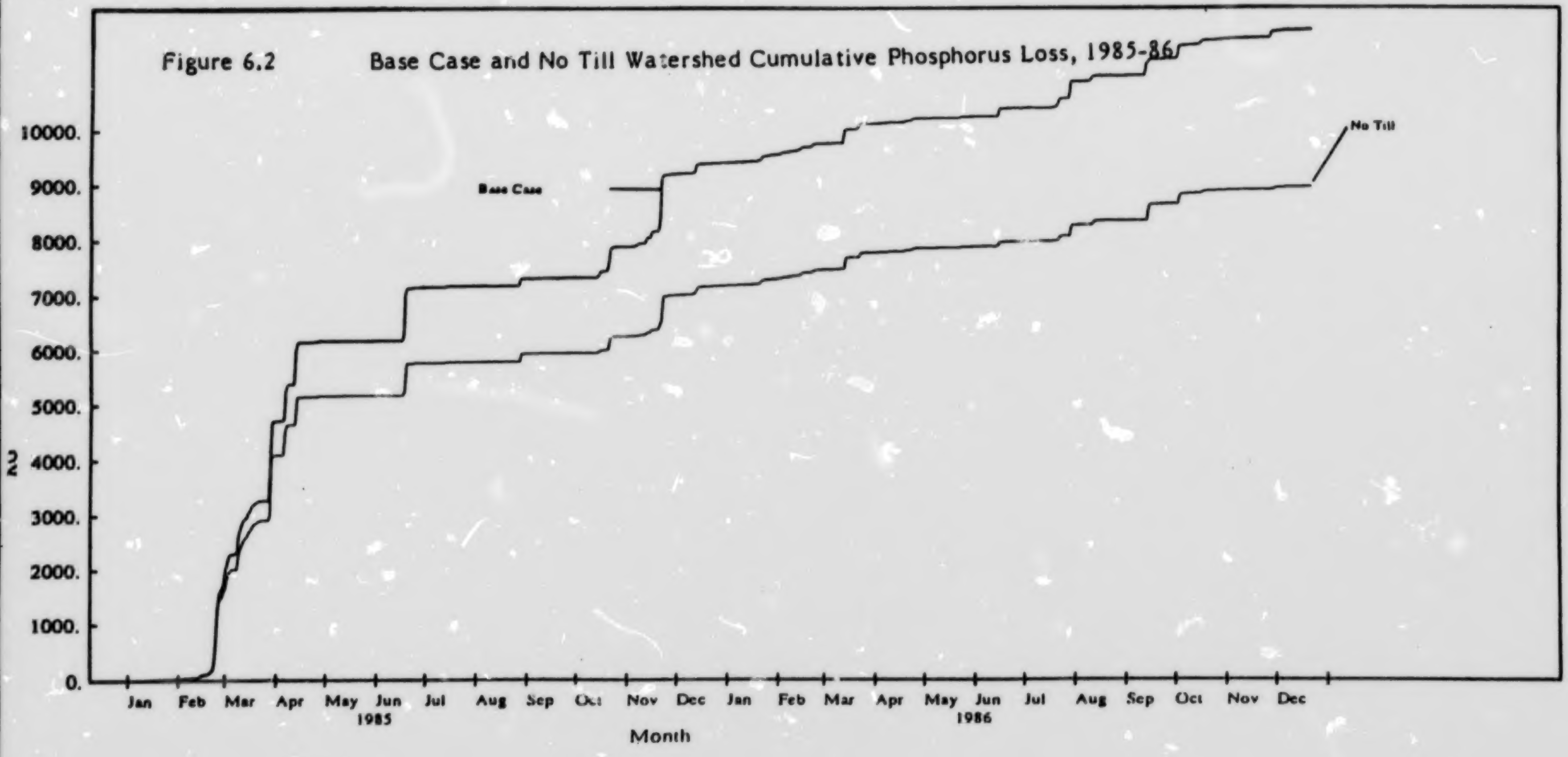


Figure 6.2 Base Case and No Till Watershed Cumulative Phosphorus Loss, 1985-86

Figure 6.3 Base Case and No Till Watershed Cumulative Atrazine Loss, 1985-86

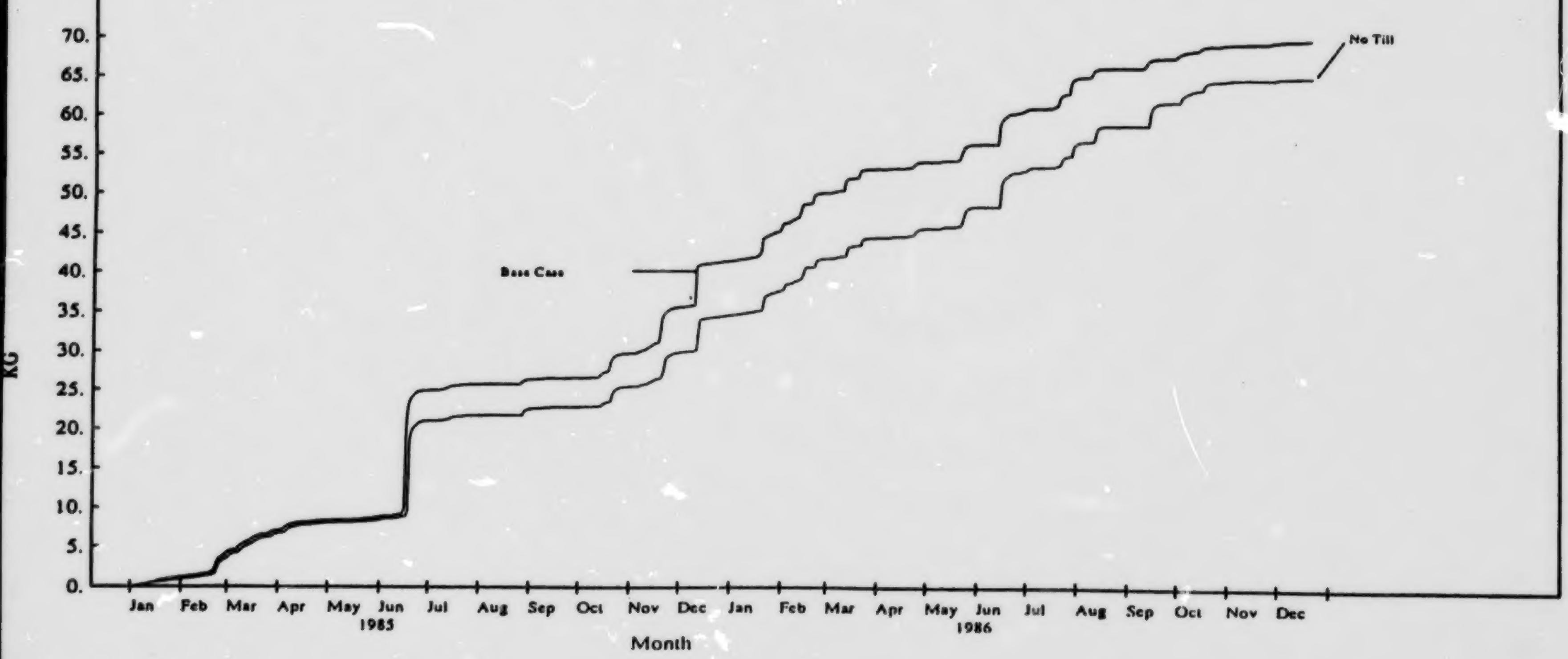


TABLE 6.2: SURFACE RUNOFF, SOIL, PHOSPHORUS AND ATRAZINE LOADINGS PREDICTED UNDER SIX LAND MANAGEMENT SCENARIOS, 1985-86

	Base Case	No Till	Strip/ Contour	Retention Basins	Tile Drainage	Optim-ization	Incorp-oration
Total Surface Runoff ($m^3 \times 10^6$)	9.82	8.54	9.54	9.82	6.92	9.82	9.82
Surface Runoff Reduction (%)	-	13.0	2.9	0	29.5	0	0
Total Soil Load (tonnes)	3,975	2,851	1,301	2,692	2,094	3,975	3,975
Soil Loss Reduction (%)	-	28.3	67.3	32.3	47.3	0	0
Total Phosphorus Load (kg)	11,394	8,558	8,492	8,975	7,007	11,394	11,088
Sediment-Associated Phosphorus Load (kg)	7,494	4,960	2,823	5,075	3,971	7,494	7,296
Phosphate Load (kg)	3,900	3,598	5,669	3,900	3,036	3,900	3,792
Total Phosphorus Loss Reduction (%)	-	24.9	25.5	21.2	38.5	0	2.7
Total Atrazine load (kg)	70.0	65.2	56.1	69.6	57.8	49.6	71.5
Sediment-Associated Atrazine Load (kg)	1.27	0.93	0.15	0.85	.40	1.2	.01
Soluble Atrazine Load (kg)	68.7	64.3	55.9	68.7	57.4	48.4	71.5
Atrazine Lost/Applied Atrazine x 100 (%)	1.62	1.51	1.28	1.59	1.33	1.12	1.65
Total Atrazine Loss Reduction (%)	-	6.9	19.9	1.9	17.9	31.0	0

- Not applicable

runoff is only marginally affected. The no till system has the potential of providing a substantial improvement over conventional systems in terms of soil and soil attached chemical loss.

6.2.2 Strip Contour Cropping

This management scenario involves cultivation in rows which are perpendicular to the slope of the land in relatively narrow strips (10 to 20 metres). Row crop strips are alternated with strips of cover crop, (hay, red clover, etc.). Since furrows run perpendicular to the slope in this case, they intercept surface runoff streamlines, thus slowing runoff, increasing infiltration and reducing soil transport capacity. The cover strips are low erosion areas and act as sediment traps for overland flow from cultivated areas thus reducing delivery ratios to the watercourse.

In assessing this scenario, considerable internal linkage changes were necessary in HSPF. Surface runoff from cultivated fields was routed to adjacent cover strips rather than directly to the streams. Sub-surface runoff from cultivated land which is tile drained was routed to the streams as before but sub-surface flow from non-tiled row crop land was routed to the sub-surface layers beneath the cover strips. The cover strips therefore intercepted surface and sub-surface runoff in this scheme.

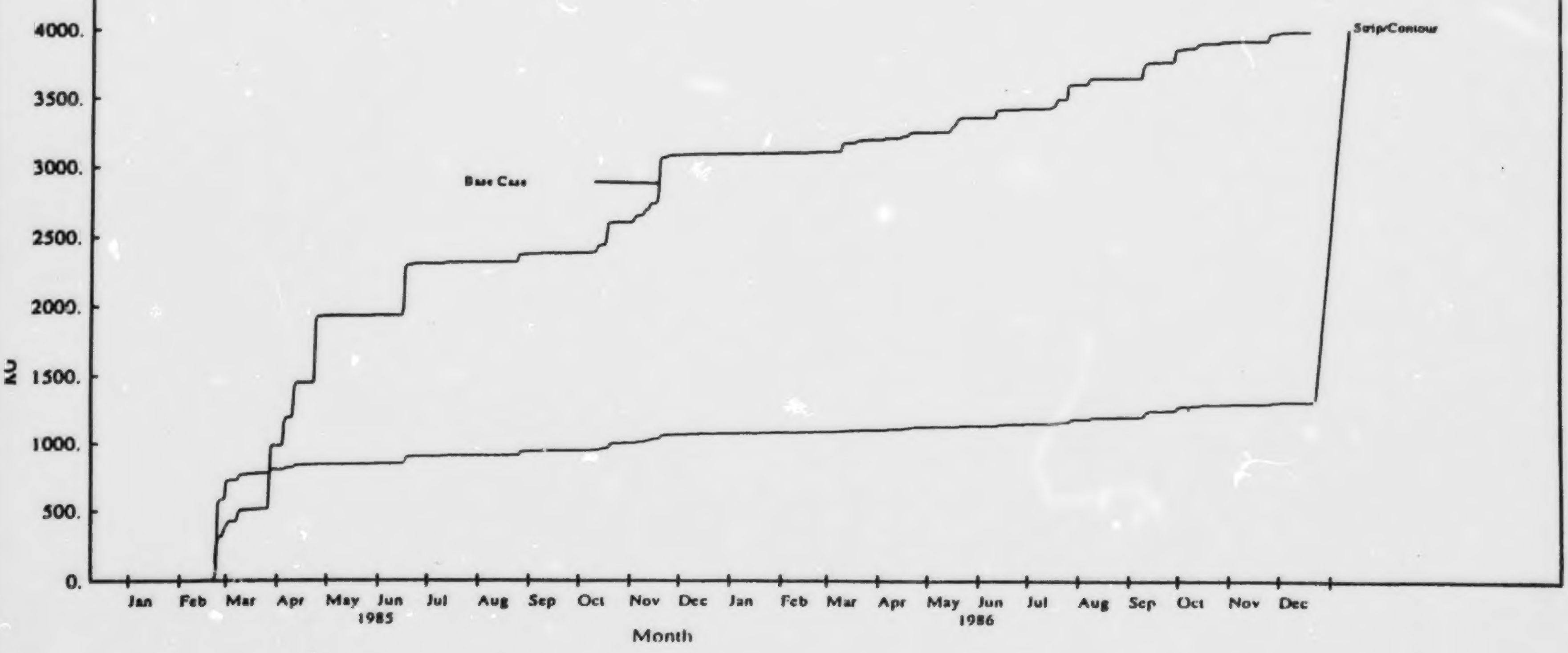
In addition to surface and sub-surface runoff routing changes, some HSPF parameter changes were made. The upper zone storage was increased to reflect the increased depressional storage that results from the rills which are perpendicular to flow and therefore act as water traps. Surface roughness was increased because of the orientation of the rills. The length of overland flow was reduced for surface flow which is routed to adjacent non-cultivated areas. The supporting management practice factor (SMPF) which is analogous to the USLE P factor was reduced as recommended by Wischmeier and Smith (1965) to account for the overall reduction in erosion sensitivity in this case. Finally, KSER, the washoff and transport parameter was reduced to reflect the lower overland flow velocities and soil carrying capacity of the overland flow.

Table 6.3 summarizes the changes made in HSPF for the strip contour cropping system. Cumulative soil, phosphorus and atrazine losses are compared to the base case in Figures 6.4 to 6.6.

TABLE 6.3 CHANGES TO HSPF PARAMETERS FOR A STRIP/CONTOUR CROPPING SYSTEM

Parameter	Meaning	Conventional Value	Strip Contour Cropping Value
UZSN	Upper soil layer storage capacity	Winter, spring and summer 15.0 mm, early fall 20.0 mm	20.0 mm all year
NSUR	Surface roughness parameter	Winter 0.15 Summer 0.25	Winter 0.25 Summer 0.40
LSUR	Surface flow path length	20-680 m	halved for all cultivated fields
SMPF	Supporting management practice factor	1.0	0.5 to 0.65 depending on slope
KSER	Soil washoff and transport parameter	.15 - .26	.08 - .13
Linkages	Routing of overland and subsurface flow	All PLS's routed to channels	All surface runoff from cultivated fields routed to non-cultivated fields. All subsurface flow from non-tiled fields routed to non-cultivated fields.

Figure 6.4 Base Case and Strip Contour Watershed Cumulative Soil Loss, 1985-86



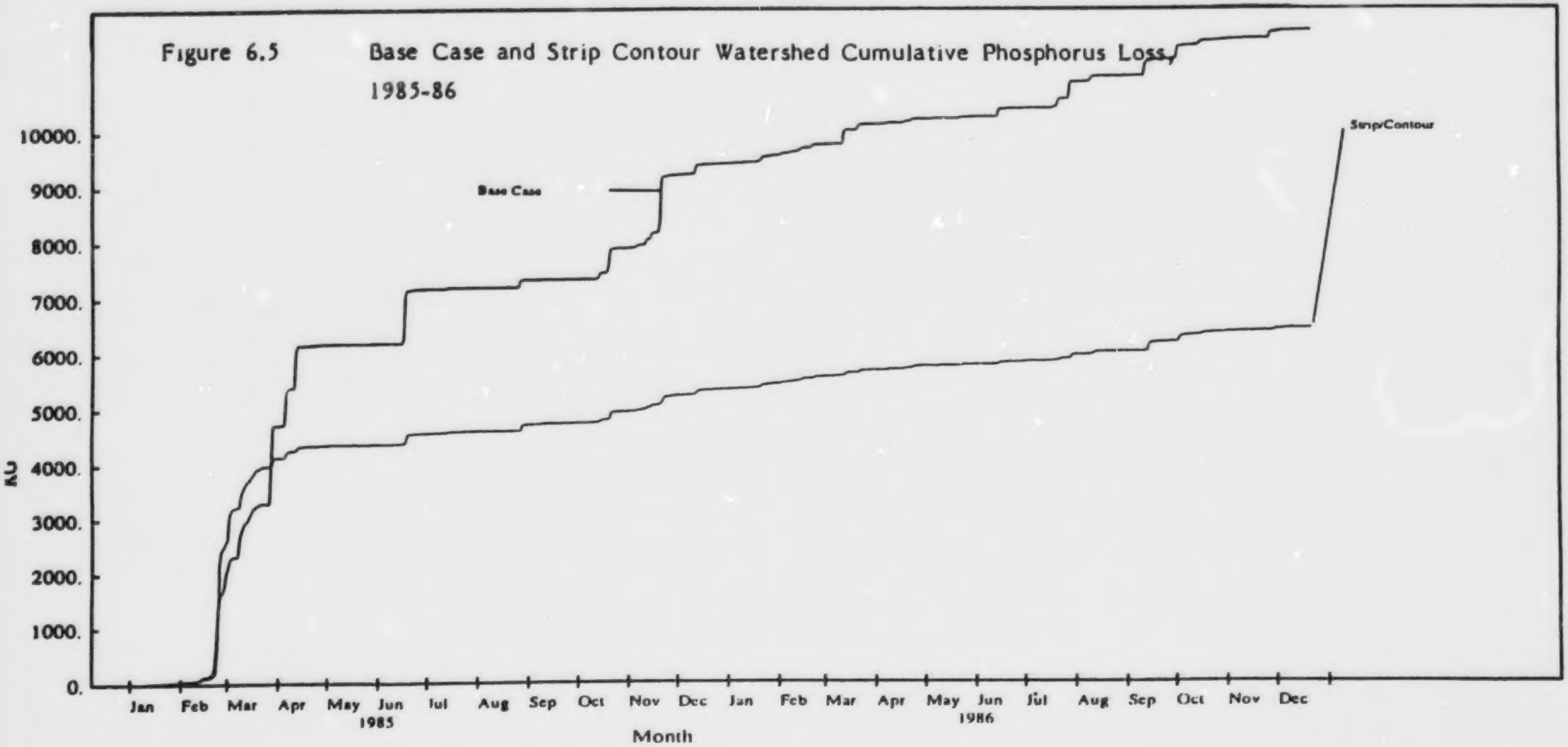


Figure 6.5 Base Case and Strip Contour Watershed Cumulative Phosphorus Loss, 1985-86

Figure 6.6 Base Case and Strip Contour Watershed Cumulative Atrazine Loss, 1985-86

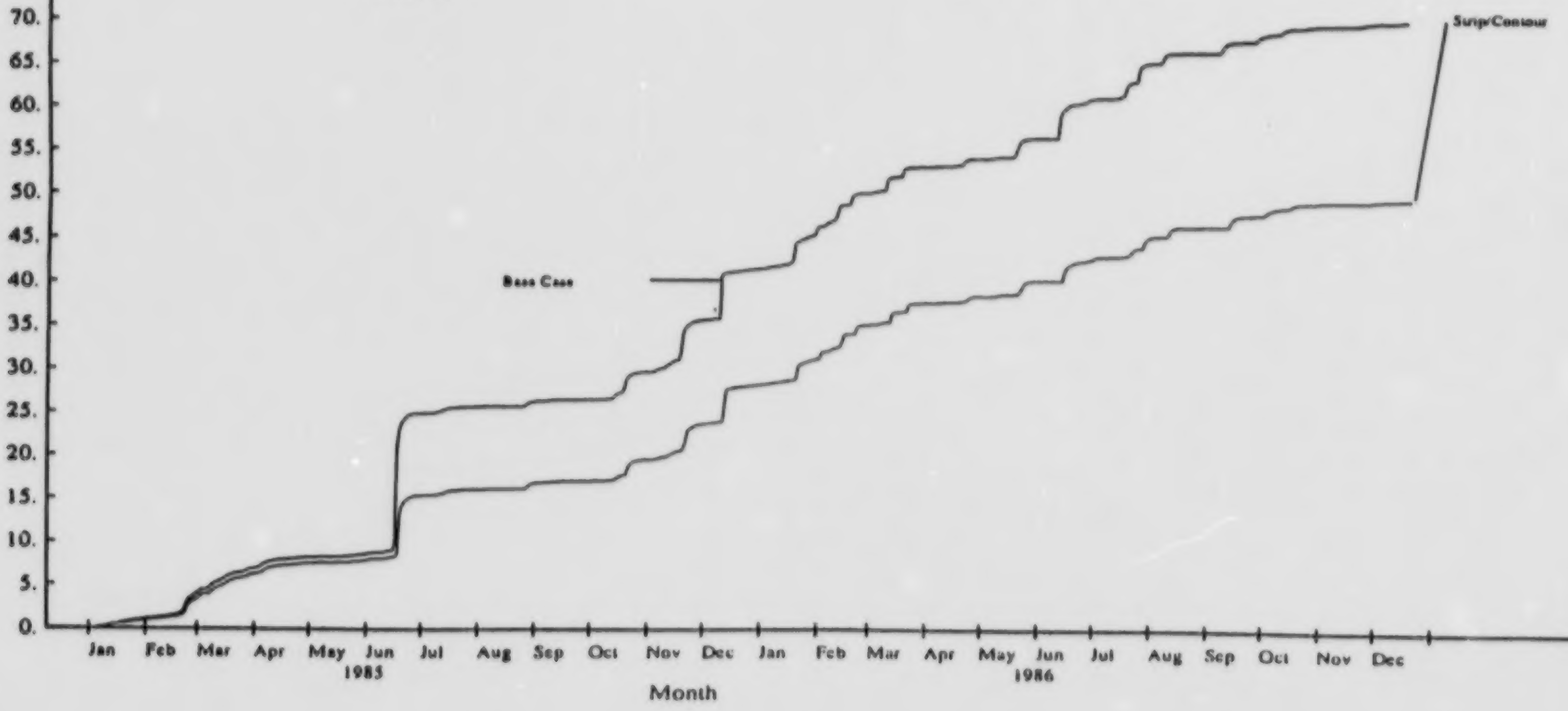


Table 6.2 summarizes the changes from the base case which resulted from these alterations for the whole watershed. The predicted runoff and transport values in this case are optimistic due to the assumptions used in discretizing this scheme and should be considered to be best case examples. Surface runoff reduction was minimal at 3%; however, soil and sediment associated phosphorus loss reductions are substantial (67% and 62% respectively). There was a predicted increase in soluble phosphorus loss which is probably due to the additional loadings introduced to the grassed strips from the row crop strips. Atrazine conservation was also high at about 20%. This is an excellent conservation scheme which requires only a reconfiguration of field crop patterns and a realignment of rows. The strip/contour system has much promise in the Ontario setting.

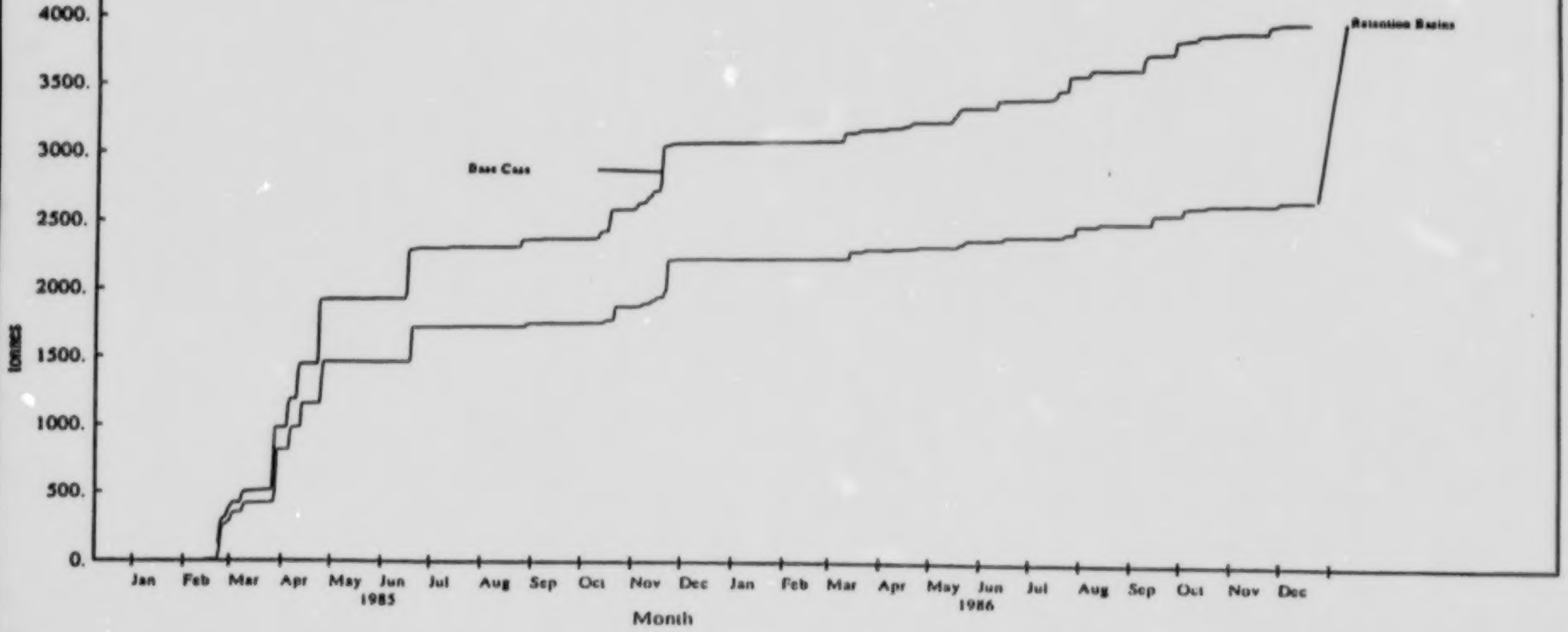
6.2.3 Retention Basins

Sediment retention basins are structural management devices which interrupt runoff or streamflow and provide for suspended sediment settling. Retention basins can be located at strategic sites throughout watershed to intercept surface runoff from erosion prone areas. Their effectiveness in removing solids from streamflow is largely dependent upon their size and storage volume and the settling rates of the various particle size fractions found in the watershed. Of course, ponds must be cleared of sediment regularly. Their effectiveness in removing phosphorus and atrazine would be dependent upon the portion of this material which is sediment associated and therefore settleable.

In this demonstration, ponds were simulated in the watershed at the end of each surface water monitoring site. That is, all streamflow passing station N4 is routed to a retention basin, and the outflow from this basin flows into the channel upstream of station N3 and so on. This scheme is somewhat simplistic as more effective sites could be selected but this scheme serves the purpose of a demonstration.

The retention ponds were dimensioned to provide a fairly constant depth of 2 metres at each site with a length of 100 metres and widths ranging from 6 metres at station N4 to 8 metres at N2 and N3 and 20 metres at station N1. Figures 6.10 to 6.12 plot the predicted cumulative soil, phosphorus and atrazine loads along with the base case predicitions. Table 6.2 summarizes the results of this scenario in terms of total loads and percentage reductions. Surface overland runoff is unaffected since this scheme has no effect on land management. Watershed soil loss is reduced by 32% in this case. This

Figure 6.10 Base Case and Retention Basin Watershed Cumulative Soil Loss, 1985-86



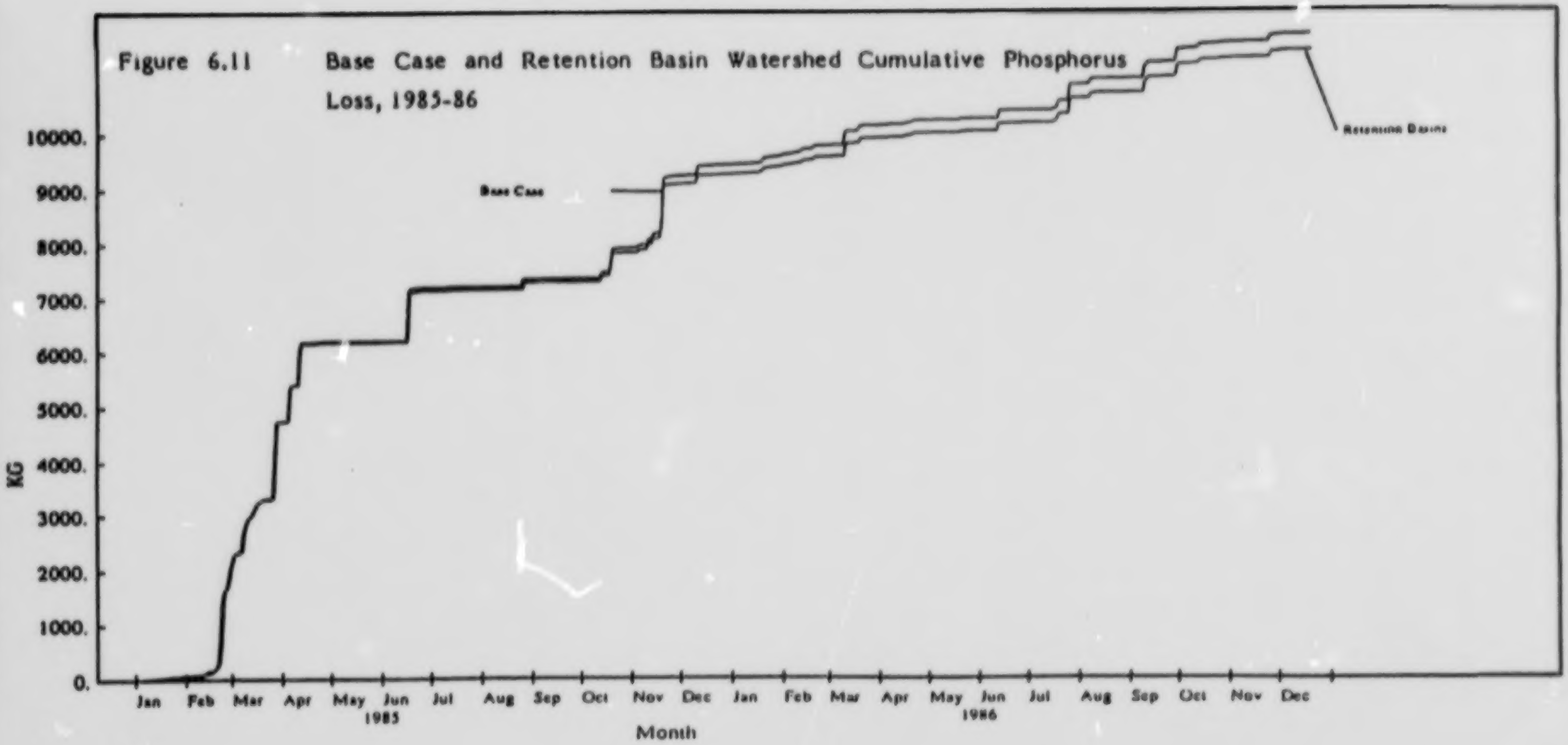
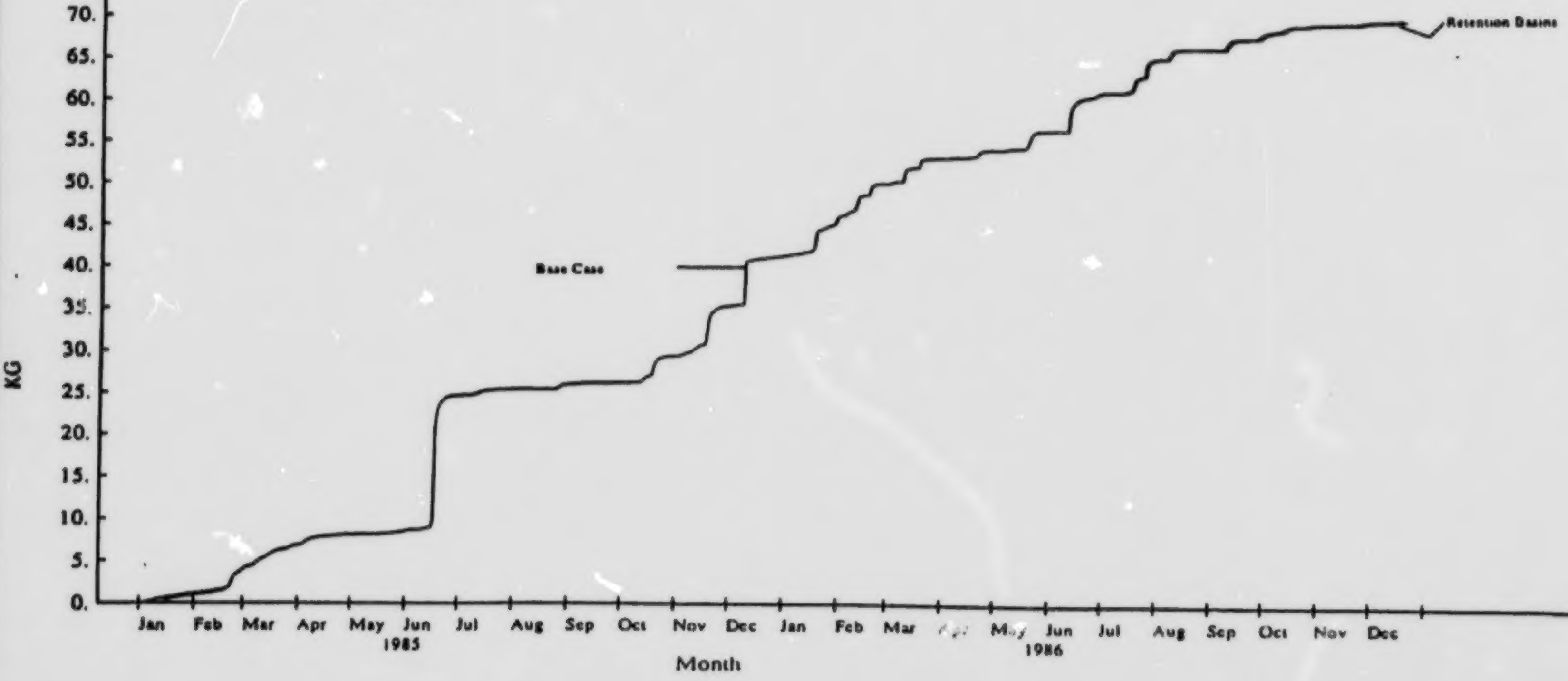


Figure 6.11 Base Case and Retention Basin Watershed Cumulative Phosphorus Loss, 1985-86

Figure 6.12 Base Case and Retention Basin Watershed Cumulative Atrazine Loss, 1985-86



material however is deposited in the settling basins and must be removed. Sediment associated phosphorus losses are also reduced (by 32%) but soluble phosphorus and the majority of the atrazine pass through unaffected. This system has limited usefulness as a stream water quality protection system. There are few advantages to the farmer since replacement of the soil onto land is prohibitively expensive. Retention basins may be useful in localized, highly erosion prone areas.

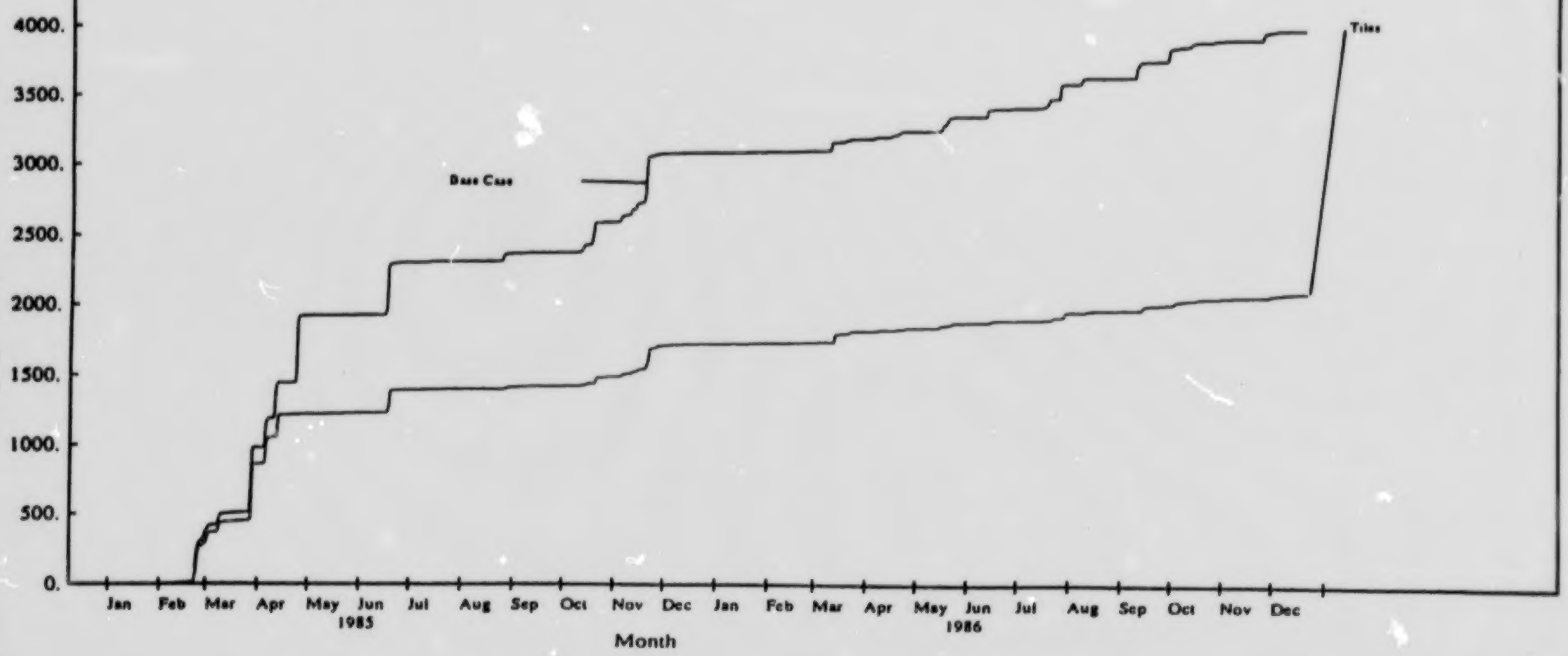
6.2.4 Tile Drainage

The Nissouri Creek Watershed has an extensive network of tile drains, both systematic and random. However, more complete tile drainage of cultivated land is possible and would result in less surface runoff by maintaining lower surface soil moisture levels. This structural scenario required only minimal changes to HSPF code. The interflow inflow parameter INTFW which controls the partitioning of sub-surface flow between interflow and groundwater was increased from a value of 2.0 for non-tiled fields and 4.0 for randomly tiled fields to a value of 6.0 for systematical tiled fields. In addition, the interflow recession parameter, IRC, was increased by approximately a factor of two depending on month, to represent a conversion to systematic tiling. These changes have the effect of routing sub-surface flow more quickly to the channels via the interflow route. This results in lower surface moisture levels and therefore more stormwater can infiltrate, thus reducing surface runoff, erosion and sediment associated agri-chemical loads. Of course better drainage also improves land capability by allowing the farmer to get on the fields earlier in the spring and by eliminating crop flooding in depressional areas.

Table 6.2 summarizes the resultant changes to surface runoff, and soil erosion, as well as phosphorus and atrazine loads for this scenario. Figures 6.7 to 6.9 compare cumulative loadings of soil, phosphorus and atrazine predicted for this scenario with the base case.

The predicted benefits of this case include 30% less surface runoff and concomitant soil loss (47% reduction), reduced sediment associated and soluble phosphorus losses (38.5% reduction) and a substantial reduction in atrazine loss (18% reduction). Tile drainage is not generally implemented for conservation purposes but it is effective in these terms and should be considered in any integrated conservation program. The return on investment of this scheme would be minimal in the Nissouri Creek Watershed because the

Figure 6.7 Base Case and Tile Drainage Watershed Cumulative Soil Loss, 1985-86



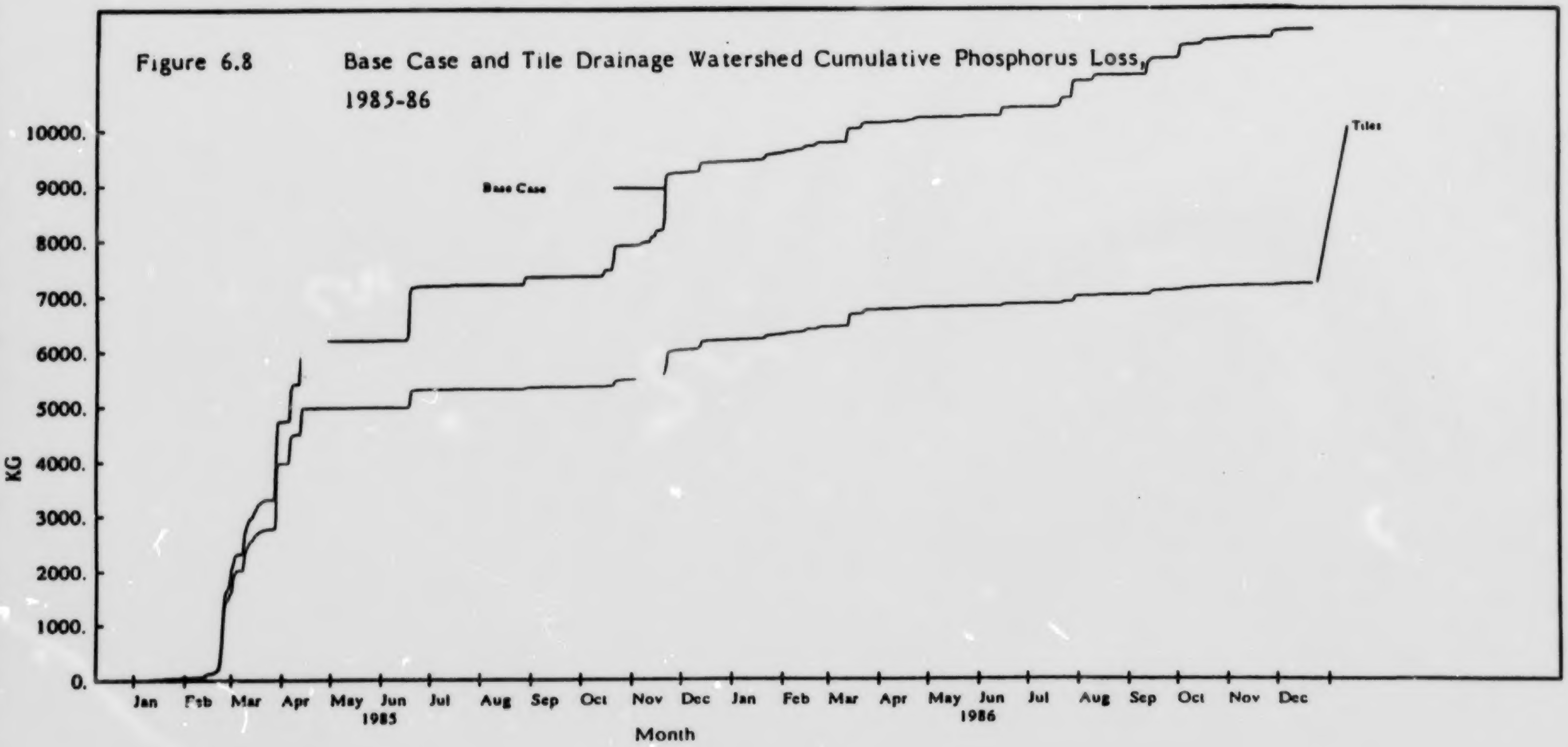
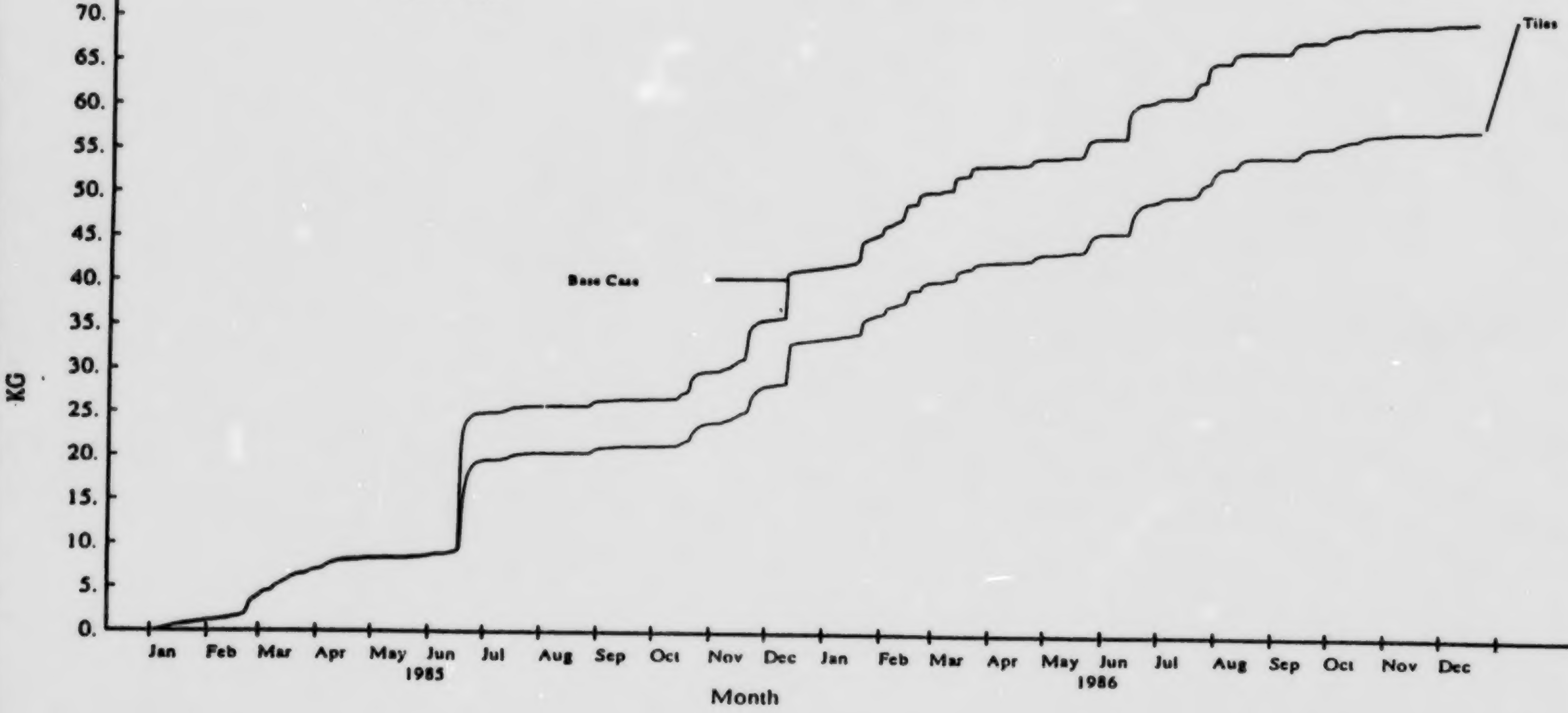


Figure 6.8 Base Case and Tile Drainage Watershed Cumulative Phosphorus Loss, 1985-86

Figure 6.9 Base Case and Tile Drainage Watershed Cumulative Atrazine Loss, 1985-86



areas which benefit most from drainage are already drained. The scheme tested here would therefore involve tiling areas which presently have fair to good natural drainage.

6.2.5 Optimization

This management scheme is a relatively passive one requiring that farmers add pesticides and phosphorus when sustained dry periods are predicted to follow. This requires that reliable weather forecasts are available and that rainfall is well spaced over the active application periods. This scheme does not affect soil loss but may reduce phosphorus and atrazine losses by allowing for chemical migration from the surface into the soil matrix, uptake by plants, and degradation (pesticides only) well before rain storms occur. Surface sediment associated and soluble runoff is most likely to be affected in the case.

To implement this scenario in HSPF the timing of soluble fertilizer and pesticide application was reset in the "Special Actions" block to correspond to times when rainfall would not occur for at least five days. Since long range forecasts are available for five days, this would be the least delay until rain that a farmer could anticipate. All other aspects of HSPF were left unchanged from the base case.

Figures 6.13 and 6.14 illustrate the results of this assessment in terms of cumulative phosphorus and atrazine loads compared to the base case. Table 6.2 summarizes the results in terms of phosphorus and atrazine pathways and percentage load reductions. No reduction in surface overland runoff, phosphorus, or soil loss is predicted. Phosphorus is only added twice per year and is quickly adsorbed by soils. Therefore a reduction in phosphorus loss cannot occur if soil loss is unaffected. Atrazine losses are reduced significantly (31%) in this case. This management scheme warrants consideration due to its relative ease of application and potential effectiveness.

6.2.6 Incorporation

This land management scheme is another relatively passive system. It requires that farmers apply fertilizer and pesticide during a tillage operation so that chemicals are incorporated into the soil rather than directly on the surface. This scheme should reduce surface washoff of freshly applied fertilizer and pesticide but will not reduce soil loss.

Figure 6.13 Base Case and Optimization Watershed Cumulative Phosphorus Loss, 1985-86

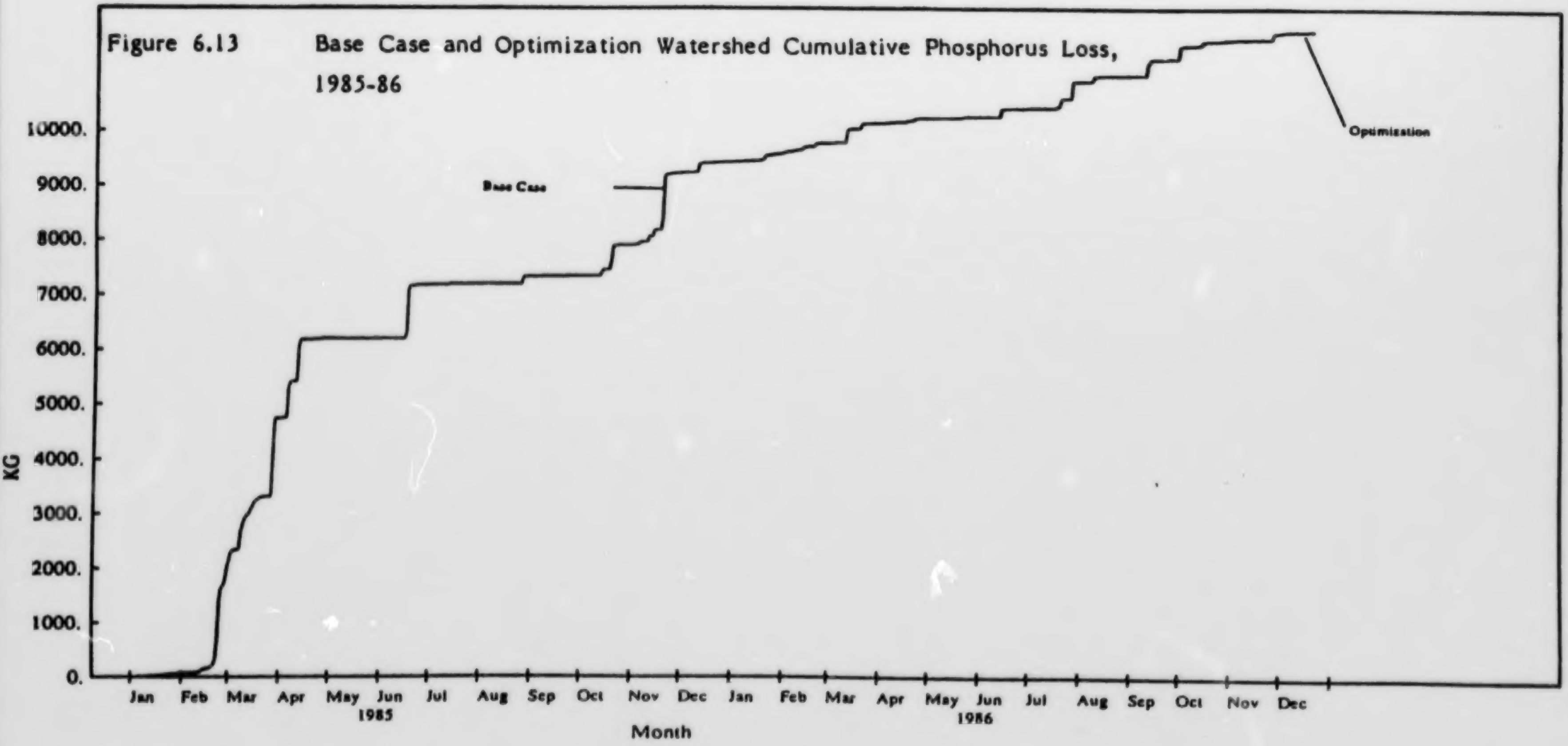
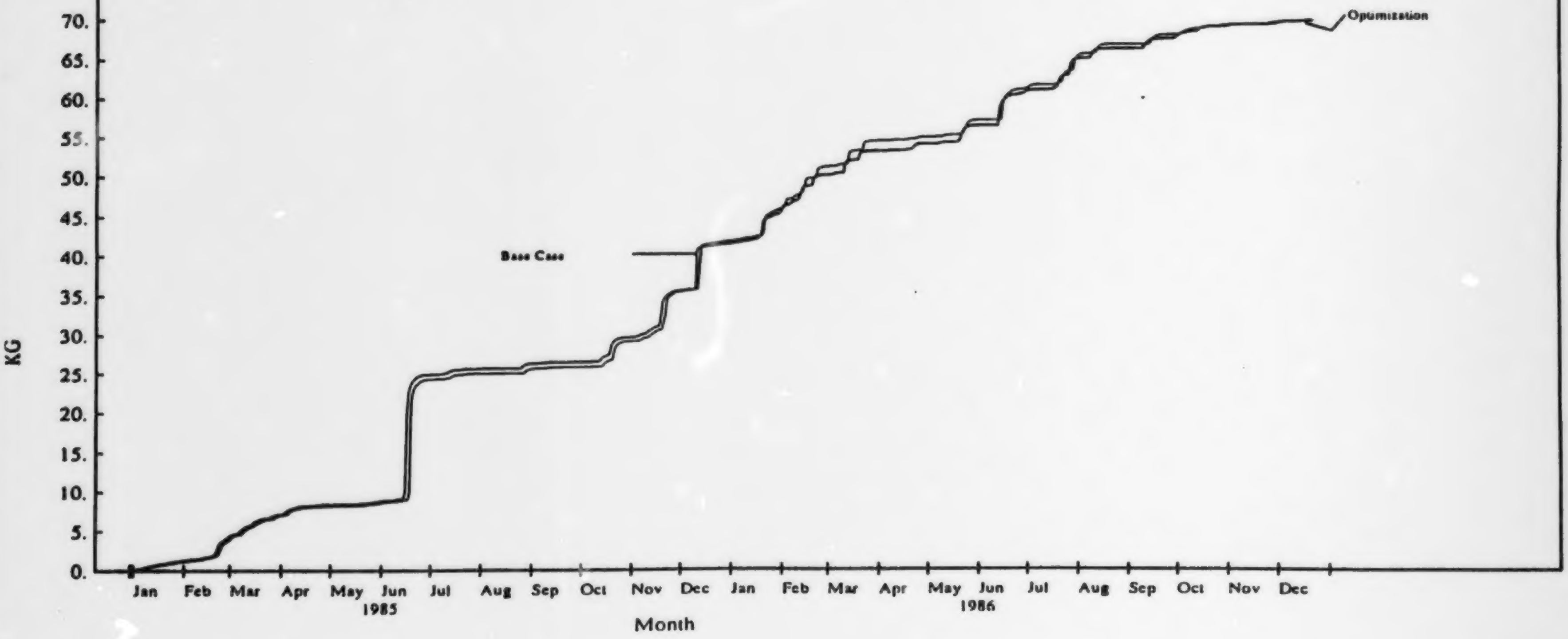


Figure 6.14 Base Case and Optimization Watershed Cumulative Atrazine Loss, 1985-86



The changes required in HSPF input are limited to simple changes in the Special Actions block involving the addition of fertilizer phosphorus and pesticide to the upper layer rather than the surface layer.

Figures 6.15 to 6.16 illustrate the predicted results of this scheme in terms of cumulative phosphorus and atrazine losses compared to the base case. Table 6.2 summarizes these predicted results in terms of pathways and % reductions.

As with optimization soil loss is unaffected and phosphorus conservation is minor. Also, atrazine conservation is not effective because most atrazine runs off in a soluble form with sub-surface flows. Incorporation would be much more effective in conserving pesticides which are more strongly adsorbed and which remain on the surface when applied in a spray form.

6.3 Utility Modules

The utility routines incorporated in HSPF allow for a variety of operations on time series data which facilitates the analysis and presentation of time series input and output. All of the utility modules are demonstrated here. The UCI for each is included in Appendix H.

PLTGEN is a plot file creation module which takes data from the TSS and performs basic aggragation upon it (i.e., grouping one hour time step data into daily output) and can be used to multiply the data by a constant factor and place it in a stand alone plot file. The plot file contains basic plotter information regarding the scale sizes, titles, and legend. Up to ten parameters can be placed in one plot file. This information can be mean valued or point valued data.

In the example presented here observed flow data for station N1 in 1986 was converted to units of m^3/day x 10^6 and plotted against precipitation in dm/day to illustrate the direct relationship between these two time series. Figure 6.17 is the plot file generated by PLTGEN. Stand alone plotting routines are required to make use of these files. The flexibility in terms of plot file formats is very broad. The UCI for this routine is included in Appendix H.

Figure 6.15 Base Case and Incorporation Watershed Cumulative Phosphorus Loss, 1985-86

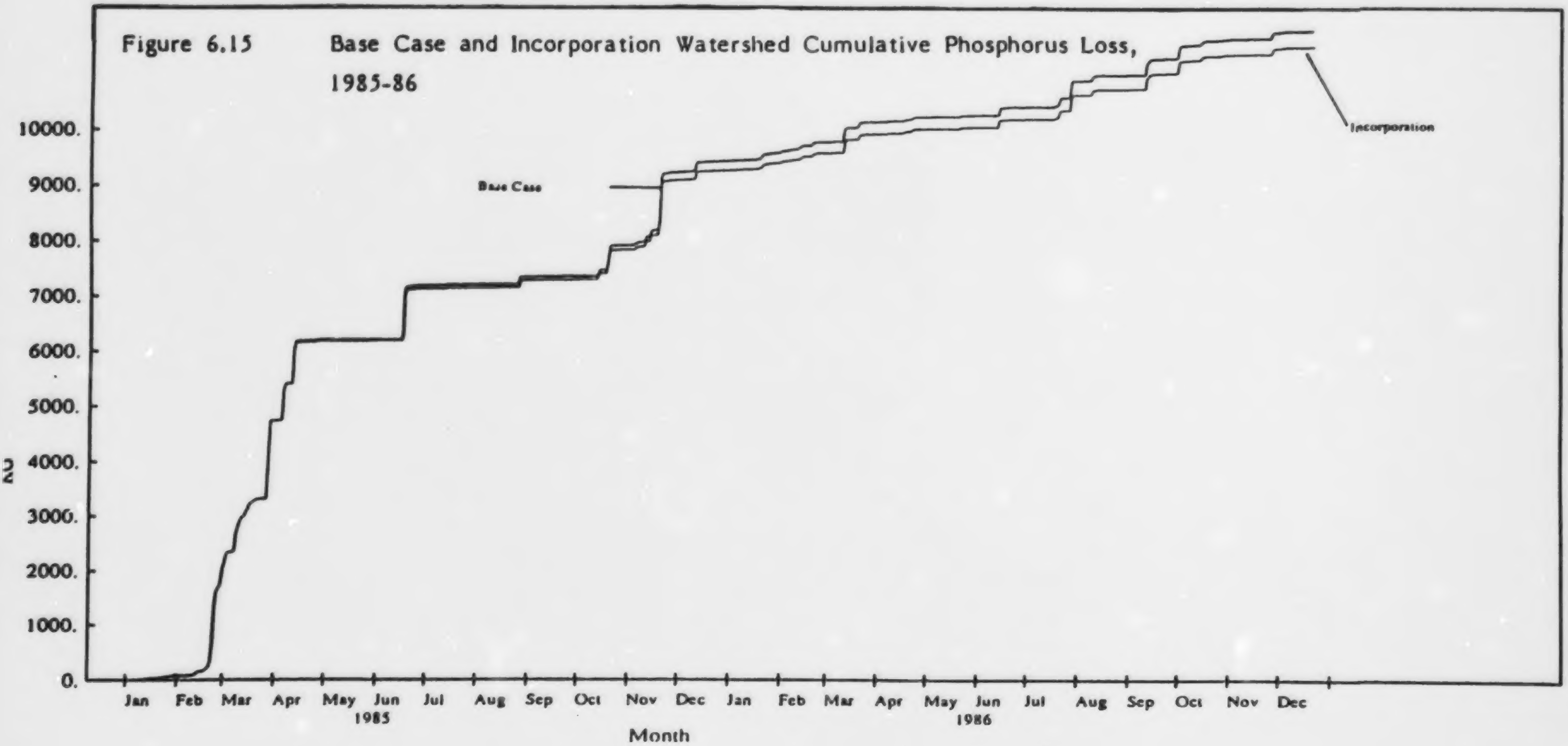


Figure 6.16 Base Case and Incorporation Watershed Cumulative Atrazine Loss, 1985-86

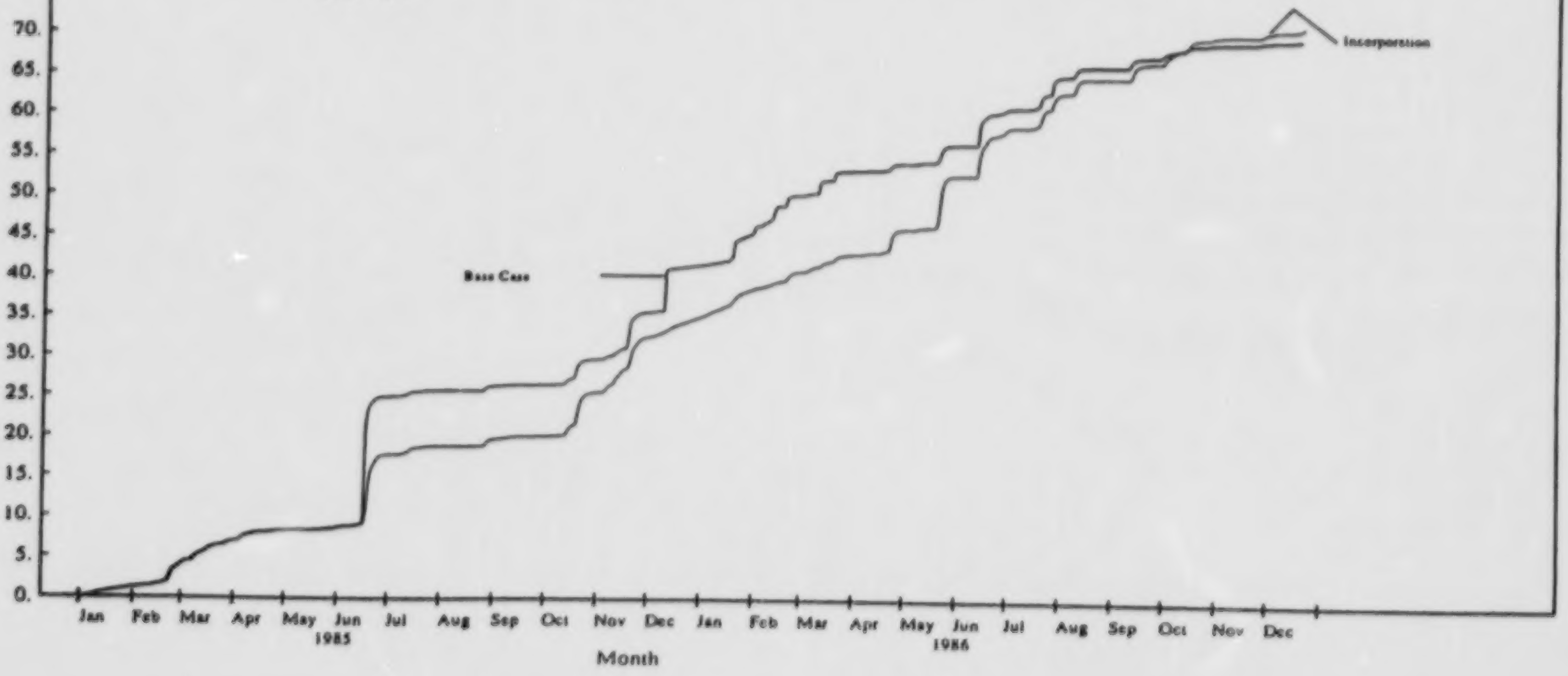
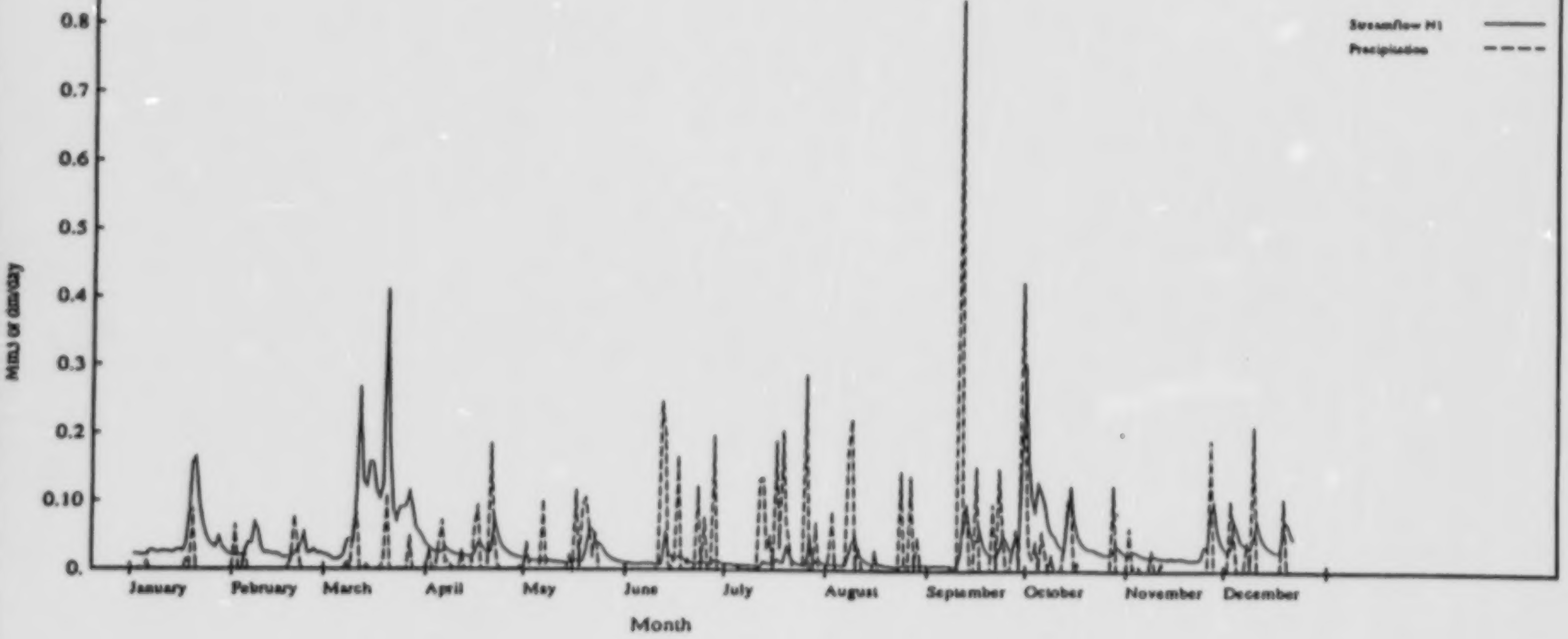


Figure 6.17 Streamflow Versus Rain-Snow, 1986



The DISPLY block is used to summarize time series data, perform simple aggragations, perform multiplication, or transformations, and present the data in tables. Data can be aggragated in short span displays with time intervals ranging from one minute to one day or left unaggragated. The data can be summarized to produce sums, averages, maximums, minimums or to select the last value in a time interval. Long span displays are annual summaries of daily data. As in short span displays, this data can be summed, averaged etc. There is no limit to the number of years presented. Threshhold values can be defined to eliminate data which falls below a particular value. This is useful in cases where only values which violate a criterion are to be printed and aggragated.

In this example, observed and predicted daily pesticide loads at station N1 are displayed in a short span (daily) form with daily total and monthly total loads; and in a long span display for 1986. The UCI and output for this example is included in Appendix H. This module is particularly useful for summarizing intermediate simulation results during the calibration process.

The GENER module is used to perform transformations on one time series to produce a second or to combine two time series by some common mathematical expression to produce a third. There are 22 basic operations which can be performed with one or two time series. If only one time series is input there are fifteen operations such as determining square root or trigonmetric functions which can be used. If two time series are input then there are seven functions such as adding them or dividing one by the other which can be performed. Refer to the User's Manual for a complete list of GENER capabilities. In this example, the predicted hourly streamflow time series for station N1 was converted to m^3/hr and multiplied by the predicted hourly pesticide concentrations at N1. The resultant atrazine loading file was displayed using the DISPLY block in the form of 6 hour loads of pesticide. The UCI and output file is presented in Appendix H.

The COPY module is used to transfer or copy data from one location to another. This includes the capability to copy files from outside of the TSS to inside, from one location in the TSS to another or from the TSS to an external file. Appendix H contains the UCI file presented as an example here. In this case, six external hourly FORTRAN files of meteorological data are copied to the TSS. The addresses in the TSS have been previously assigned (#'s 11-15 and 18) and named (PRETB1, PRETB2 etc.). This data is mean-valued, metric, sequential data which is to be added to any existing antecedent data already in the TSS. Existing data for the same time periods will be overwritten. Data can be multiplied by a factor if for example one wished to perform a units conversion. Also the data can be transformed by up to 8 transform functions.

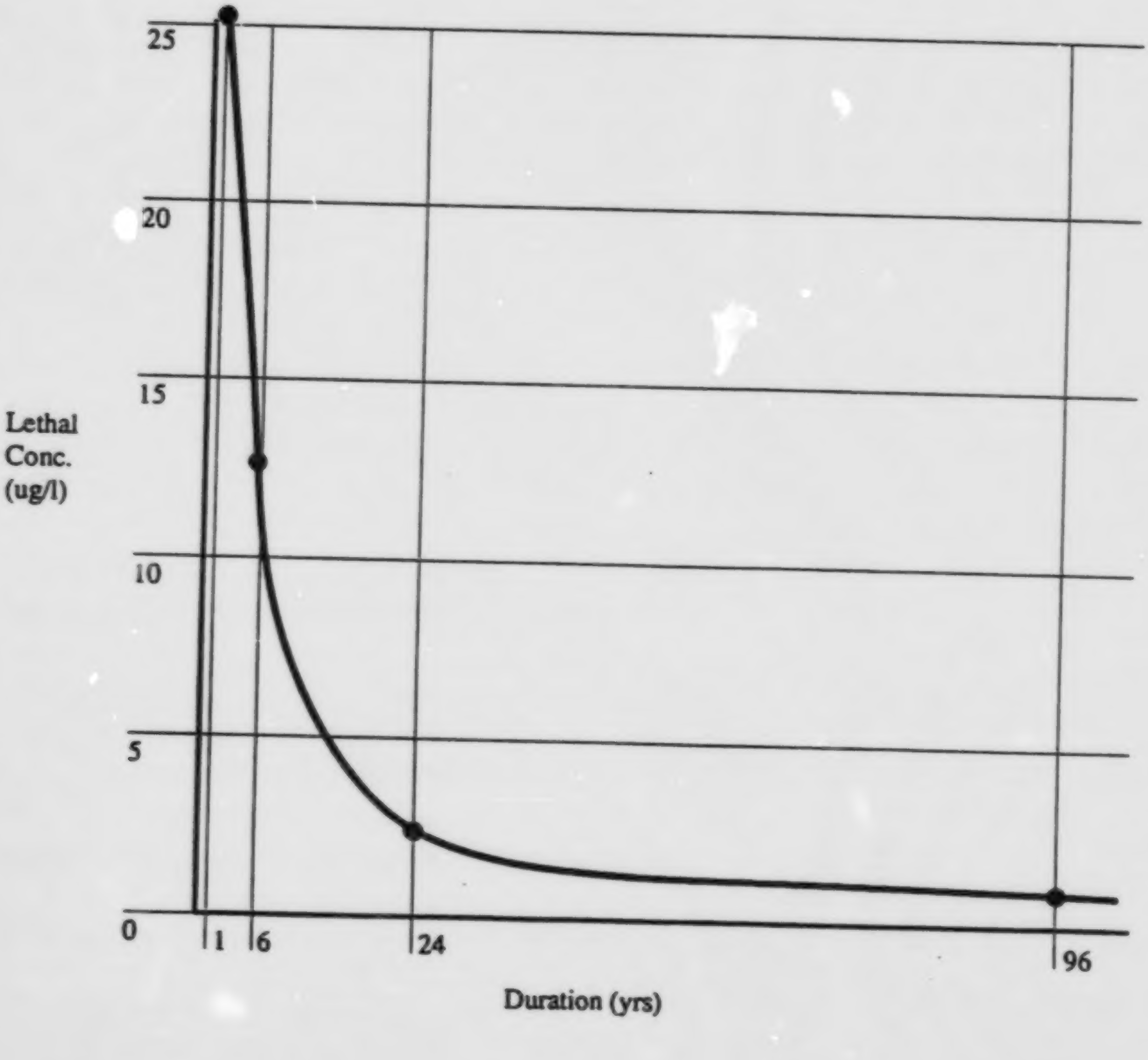
The DURANL module is an interesting example of a data analysis and assessment facility linked with a simulation model. This module performs duration and excursion analysis on a time series. That is, the frequency of a specified concentration being exceeded is summarized. In addition, the length of the excursions above the level is analysed for up to 10 different time durations. Analysis can be limited to a particular season or seasons if desired.

A lethality analysis can also be performed on the time series data. If toxicity information is available in the form of a curve specifying lethal concentrations versus exposure duration then DURANL will summarize the number of times that concentration and exceedance duration combine to cause a lethal situation.

In an example (see UCI and output in Appendix H) the 1986 hourly predicted concentration of atrazine at station N1 was the subject time series. The season selected for analysis extended from March to November only. Four duration periods were defined; one, six, twenty-four and ninety-six hours. The specified concentration levels are 0.05, 0.01 and 0.5 ug/l. A lethal concentration was also specified for each duration to produce the lethal concentration curve of Figure 6.18. Up to five different curves could have been specified. This curve is not a real lethal concentration curve since the lethality limit of atrazine was never reached in this study. It is used for illustration only. The predicted 1986 atrazine concentrations never exceeded the estimated rainbow trout 96 hour LC_{50} value of 4.5 mg/L (Agriculture Canada, 1982). The highest observed instream concentration in 1986 is 350 ug/l.

The DURANL output has been printed to the second highest level of detail. The output indicates that 68.17% of the time (from March to November 1986) a level of 0.5 ug/l was exceeded for at least one hour and so forth. This type of information is summarized in several slightly different forms. In terms of the lethality analysis, the output reports a summary table for each lethality curve. In this case, it is reported that the lethality curve was exceeded 24.92% of the time. The output also reports the time and duration of each exceedence.

FIGURE 6.18
DURANL Lethal
Concentration Curve



The DURANL module is ideal for analyzing the effect of land management scenarios on instream toxicity in one smooth operation. Other possible applications include low flow statistical analyses for long term flow records or any analyses of violation when the violation criterion is a function of duration.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Study Area

The Nissouri Creek Watershed was well selected for this study for several reasons. These include:

- in terms of soils and potential erodibility it represents a significant portion of the agricultural area (3,050 km^2) of the Lower Great Lakes drainage basin.
- the watershed is sufficiently small (31 km^2) that the collection of land use information (for 55 farms) and other areal attributes was possible within the limits of the program. Also because of its size and hydrologic characteristics, the main stream channel flows continuously. This provides for continuity in the flow and water quality data and allows for reasonably accurate flow estimation.
- the use of pesticide was widespread and corn fields were almost exclusively treated with atrazine.
- the area does not have confounding features such as a major point source of pollutants, significant non-agricultural areas, or significant stream bank erosion.
- a historical data base which includes loading information for sediment, phosphorus and atrazine exists for two years in the mid 1970's. Also detailed soils, topography and land use has been defined in the PLUARG study. Much of this information is relevant for the 1985-86 period.
- the local land owners were generally co-operative.
- land management practices were generally conventional thus the worst case was represented. This is ideal for assessing benefits of conservation practices.

- large areas are tile drained thus allowing for examination of the interflow component.

These factors are all very important considerations in selecting test catchments for research purposes.

It is recommended that streamflow and water quality monitoring continue in the Nissouri Creek Watershed at the watershed mouth station, N1. This watershed has one of the largest and most complete historical records of agricultural chemical loadings in Southern Ontario. As farming practices change in the future it can be used as a bench mark to assess the benefit of conservation farming. The existing and proposed future databases for this watershed can be used for model development, pesticide and plant nutrient loading assessments, and soil erosion control and transport/transformation process research.

7.2 Field Studies

The field studies implemented as part of this study were successful in providing the necessary time series and overall process parameter data for model calibration and validation as this study is primarily intended as a model demonstration exercise. The monitoring program was not designed to provide for a rigorous analysis of specific transformation and transport processes at the field level (5 to 20 hectares) or microscale level (1.0 to 1,000 m^2) with the exception of the field level atrazine decay studies conducted by MOE. A more integrated approach involving continuous and event based monitoring at several scales is necessary for detailed process research and for assessing the potential benefit of conservation farming. Monitoring instruments were generally reliable and along with the sample handling protocols which were adopted a high degree of quality control was assured. However, recognizing that improvements can be made and taking advantage of "hind sight" the following recommendations for future studies are presented:

- the prediction of sediment transport and model calibration could benefit from more detailed information on stream channel hydraulics. Information on channel dimensions, typical velocity profiles, streambed erosion prone areas, and time of travel data would aid in estimating suspended sediment transport and improve the delivery timing processes.

- the effect of weeds on stage/discharge curves at station N3 became a problem in the summer months despite efforts to alleviate the distortion. Other measures to reduce the weed growth (ie, pesticides or channel liners) should be considered. Alternately, fixed weirs can be built into the streambed to provide a reliable control section.

- evapotranspiration is a major component of the watershed water balance. This process is difficult to measure but accurate evaporation rates can provide a good upper limit on evapotranspiration. The device used in this study (a wet bulb type of evaporation meter) did not provide reliable results. Evaporation pans should be used to estimate this parameter.

- infiltration is a key parameter in determining surface runoff rates. Some measurements of infiltration at different times of the year, in different soils and at different depths would be valuable in model calibration.

- adsorption and desorption measurements of phosphorus would be valuable in refining estimates of adsorption/desorption isotherms for the predominant surface and sub-surface soil types.

- groundwater levels at several sites should be monitored for water level as an indication of the groundwater storage component and the depth to groundwater. This parameter is easy to measure once observation wells are in place.

- field level studies are valuable for measuring and estimating process parameter values. Additional field studies designed to measure sub-surface flow and sub-surface phosphorous and pesticide loading rates would be valuable. Also field level monitoring of soil washoff would be very useful.

- microcosm measurements of soil loss using a rain simulator device is another way to gather valuable information on soil erosion and washoff and aid in estimating relevant parameters for conventional and conservation management systems.

- continuous measurement of tile drain flow in some selected areas would be useful for partitioning sub-surface flow between interflow and groundwater discharge.

- the majority of farmers in the Nissouri Creek Watershed freely provided information regarding atrazine use during the study period. Additional information including tillage practices employed and the timing of field operations, crop yields, pesticide application practices, tillage implements used, a history of crops grown on each field, and detailed information about sub-surface drainage networks are necessary for in-depth agricultural erosion and runoff studies. It will be necessary to establish a cooperator program including monetary compensation to achieve this level of feedback in future studies.

- snow surveys should be conducted on several occasions during the winter months to estimate the water equivalent storage in the watershed. Rain gauges are universally unreliable for estimating snowfall. In addition, blowing snow and sublimation can significantly modify existing snow stocks in a watershed necessitating estimation of the state of the snow pack directly.

7.3 Modelling

Setting up the HSPF input and calibrating HSPF is a substantial task. There are no short-cuts to accomplishing accurate calibration however, a systematic approach to the problem is recommended. Chapter 5.0 included a description of the steps required in applying the model. Each of these steps should be given due consideration in order that expectations match model performance, that unnecessary model modules or groups are not invoked, that input requirements are satisfied, and that the most optimum strategy and conceptualization of the study area is used.

In model calibration, an understanding of what is important and what is not, is essential. A review of the Functional Descriptions Section in the User's Manual is advisable. In addition, the parameters which are suspected to be important should be subjected to a sensitivity analysis. A sensitivity analysis is a way of evaluating the overall effect of one parameter at a time on model results. Model parameters should be reasonably well initialized however before this is done. These parameters which are found to be relatively unimportant should then be set, based upon the best information available. The parameters resulting in significant model sensitivity should then be systematically eliminated as variables by calibration.

In this study the hydrologic parameters, starting with the snow-accumulation and melt parameters, were calculated first. This entailed about 16 parameters and starting conditions. This was, by far, the most difficult phase of the calibration process because of the large number of degrees of freedom and the reliance of all other modules on the hydrologic model. This process is best accomplished by establishing observed state conditions to which the models parameters can be adjusted. In the case of the hydrologic model, monthly outflow was an important parameter for determining whether the various storage components were in balance and whether the evapotranspiration rates were appropriate. Observed single event hydrographs were compared with predicted event flows as a means of evaluating the surface run-off and interflow constituents. In fact, many ways must be established to evaluate the various model subcompartments in order to eventually bring all compartments into balance.

The calibration of the sediment-soil loss modules required that more than 10 sensitive parameters be established. Calibration of the agri-chemicals sections for phosphorus and atrazine each involved about ten parameters plus another eight for soil temperature and moisture.

The model catalogues found in the User's Manual provide a listing of a wide variety of optional model output information. The whole process can be greatly facilitated by carefully designing the output data to provide the information necessary to evaluate particular parameters. The model user must become adept at "tuning the model" and must constantly modify the various flags, options and output types throughout the calibration process. Calibrating a complicated model such as HSPF with many degrees of freedom is to some extent an art and a science like tuning a piano. The modeller must use all of the quantitative evaluation techniques that are available but the final tuning is a matter of intuition and balance that comes from experience and judgment.

It is recommended that new users of HSPF start with projects of limited scope and approach larger tasks only after they have gained the experience and confidence necessary. In addition, the model user should assemble auxilliary programs to aid in plotting results as this is one of the best means of assessing intermediate results in calibration.

Rapid turnaround time is essential to HSPF calibration and application necessitating relatively powerful computers. A SUN Microsystem 3/75 workstation was used in this study. It provided model output within an hour for most runs. Without this rapid feedback the model user will become frustrated awaiting results and considerable inefficiency can result. While a personal computer version of HSPF is available, it cannot process the more ambitious modelling runs involving water quality parameters.

7.4 Model Application

A great deal more effort has been expended to develop land management models such as HSPF than to demonstrate and quantify the effects of various land management practices on soil and agri-chemical washoff. While erosion and the washoff processes are well understood in conceptual terms, our ability to quantify the degree of change which can be expected from a particular practice or by use of a particular type of farm implement, is in the early stages of development.

Our review of the literature, discussions with conservation experts and application of HSPF leads to one overwhelming conclusion. If models such as HSPF are to be accurately used to predict soil and agri-chemical losses from agricultural areas under proposed conservation management schemes then more research must be directed to establishing the parameters of change. The research community must work towards developing reliable guidelines which will aid the modeller in selecting reasonable parameter values for all management practices. HSPF has the framework to simulate a wide variety of optional schemes but its overall ability to accurately predict depends upon the model users ability to select realistic parameter values. The U.S. experiences in the Iowa, Michigan, and Georgia watersheds have been valuable in this respect. An Ontario table of erosion and chemical transport parameters is needed. At present, pieces of relevent information exist but the matrix is far from complete.

The application of HSPF to assess best management practices described in the previous chapter was intended as a demonstration of HSPF capabilities and sensitivities only. It was not intended to be a reliable assessment of the six practices per se. The model was shown to be generally sensitive to changes in these factors and conditions which are most directly affected by a change in land management practice. However, the degree of change in any single factor cannot be accurately predicted at this time. Therefore, reliable quantitative estimates of long term best land management practice benefits cannot be made at this time.

Mathematical models are powerful tools that greatly improve our ability to evaluate land management practices as they affect the local environment. Without models in convervation planning, we could compare streamloads of phosphorus and suspended sediment between improved and unimproved watersheds. If all relevant land attributes and land use are fairly similar with the exception of land management practices, then we could draw conclusions about the gross improvements in terms of our evaluation criteria. However, if significant differences exist in watershed characteristics (which is surely to be the case) then our conclusions would become clouded by doubt. We would have no rationale for extrapolating our study results to other areas or for scaling up to primary watersheds. The PLUARG studies of the 1970's were limited in their value because of the lack of conclusive cause and effect type research and predictive technology. Models allow us to account for variation in watershed attributes and apply our knowledge over a widespread area.

We recommend a three level approach to modelling for the development of farm conservation plans. These models would be used for different and specific reasons. Screening level models or techniques can be used to identify erosion-prone problem areas within watersheds so that the most "improveable" areas are identified for improvement and erosion control. Little would be gained by targetting erosion resistant areas or areas with large sediment traps for extensive improvement. The Universal Soil Loss Equation provides the computational complexity required at this level. Several models are available which expand the USLE and offer convenient techniques for a screening level analysis. These include:

- The Environmental Conservation Service/Lands Directorate Manual for Regional Targetting of Agricultural Soil Erosion and Sediment; and

- The Haith model for estimating chemical losses from agricultural areas (Haith, 1980).

These models are simple and economical to use and thus satisfy the requirements at the level required to screen watersheds for problem areas.

The second level of evaluation is useful in evaluating management practices in a field level (small scale). Models suitable for this purpose can be applied to determine the expected improvement resulting from the implementation of BMP's at the field level. This analysis should be part of farm plan implementation.

As land management practices are improved in watersheds and soil and phosphorus runoff data is compiled, the second level models can be calibrated and used to determine the environmental changes that result. In terms of soil loss, all or some of the values selected for the USLE factors such as "K", the erosion index, "C", the cover parameter and "P", the management practice factor, can be refined. The second level models can be used to quantify this change for specific areas and systems when follow-up monitoring is possible.

Models for consideration at this level include:

- GAMESP - the Guelph Model for Evaluating the Effects of Agricultural Management systems on Erosion, Sedimentatin and Phosphorus yields, developed at the Univeristy of Guelph School of Engineering.

- CREAMS - Chemical Runoff and Erosion from Agricultural Management Systems, developed by the U.S. Department of Agriculture.

These models are capable of simulating the loss of soil from agricultural areas through the use of the USLE concepts and have been improved to include delivery terms. The GAMESP model allows for a seasonal or annual prediction of soil and phosphorus losses from surface runoff. The CREAMS model has similar capabilities but includes nitrogen and pesticide runoff and transformation and is a continuous simulation model. HSPF can also be used as a screening tool and for identifying "hot spots" which are prone to erosion but unless more detailed quantiative information is required, the HSPF approach could be overly complex.

The third most intensive level of evaluation requires a comprehensive continuous simulation model for evaluating the full repercussions of BMP's. At this level, all significant aspects of the watershed's hydrologic cycle can be simulated along with soil loss and phosphorus transport. It is recognized that land management affects watershed hydrology which in turn affects soil and chemical loss. For example, it has been demonstrated that tile drainage reduces surface runoff in poorly draining areas and this results in reduced losses of phosphorus via surface runoff. However, it has also been shown that tile drainage can affect the movement of atrazine from fields and influence the extent to which phosphorus losses are controlled by conservation tillage. We believe it is essential to develop an understanding of phosphorus and other agri-chemical movement via subsurface flow in order to properly assess land management practices.

The watershed hydrological and water quality model, HSPF has had widespread application in Canada and the United States. It is the most comprehensive model available for this level of analysis. It is "state of the art" in many respects and also provides the framework for future improvement in process description. We recommend that HSPF be adopted as the standard for comprehensive watershed modelling, especially when agricultural activities are an important element or when BMP's are to be evaluated.

7.5 General Conclusions and Recommendations

Based upon the experiences and observations of the study team, the following conclusions and recommendations have been drawn.

- o watershed studies provide the most productive means to quantify farm impacts upon surface waters. Streamflow and water quality measured at the mouth of a watershed are a direct result of upland activity and natural process. The watershed is a self contained unit, complex in its structure, yet discrete and independent from the surrounding areas. All processes and material pathways are integrated at the watershed mouth. The groundwater and the drain systems generally closely match the surface area and therefore mass balances can be developed at the watershed scale. Watershed studies should be extended over several years so that the effects of meteorologically abnormal years are reduced. In some cases, the effects of land management may take several years to be apparent.

- continuous monitoring for streamflow and flow proportional water quality sampling provide accurate measures of stream loadings. In addition, this monitoring scheme is cost effective in that sample analysis costs can be minimized. Recent developments in automatic sequential samplers and flow meters allow for reliable monitoring, and reduced manpower costs without sacrificing quality control.

- site specific meteorological monitoring is a key component of watershed runoff studies. The spatial heterogeneity of precipitation and microclimatic phenomena reduce the representativeness of regional climate information. Detailed runoff models cannot be accurately calibrated without local climate data. Precipitation collectors should be placed at areal densities of at least one gauge for each 5 square kilometre area and if possible up to one gauge for every one to two square kilometres.

- sub-surface pathways (i.e., groundwater and tile drains) can be significant routes for the movement of phosphorus and atrazine from agricultural areas. In some cases soil can also move into tile drains where macro pores and breaks in the tiles exist. Agricultural runoff studies should address these components in addition to surface runoff. In this study up to 40% of all phoshorus and 57% of the total atrazine was estimated to enter the watercourse via tile drains and groundwater. Pesticides with higher solubility in water and lower affinity for soils than atrazine will partition more to the sub-surface routes than atrazine and will therefore tend to move with baseflow.

- In the Nissouri Creek Watershed, the movement of soil, phosphorus and atrazine to the watercourse was highly dependent upon the occurrence of the rare warm weather intensive storm. About 45% of all soil loss, 38% of all phosphorus loss and 56% of all atrazine loss occurred during eight major warm weather storms over a twenty-four month period. These eight storms accounted for only about 26% of the total measured warm weather precipitation. Less significant precipitation events which accounted for 74% of the total warm weather precipitation resulted in only 20% of soil loss, 13% of phosphorus loss and 34% of atrazine losses.

- during this study snowmelt periods accounted for over 80% of all overland surface runoff. The relative proportions of soil, phoshorus and atrazine loss during these periods was much less at 35, 49 and 10% respectively. Frozen surface soils and snow cover during these periods reduced the impact of rainfall and protects against rill and gully erosion. Snowmelt periods do result in significant daily loadings of soil and soil attached chemicals although suspended sediment and chemical concentrations during these times tend to be less than those during warm weather storms because of runoff dilution.

- antecedent conditions are highly important in terms of determining the partition of fresh rainfall between surface overland runoff and sub-surface runoff. Storms which occur when soil moisture levels are high result in high surface runoff and "spiked" hydrographs. Storms which occur when soils are dry result in replenished soil moisture levels, increased baseflow and very little or no surface runoff. The large majority of rainfall events did not result in significant surface runoff in the Nissouri Creek Watershed from 1984 to 1986.

- HSPF is a reliable model for predicting streamflow, as well as soil, phoshorus and atrazine movement from agricultural watersheds. This model contains sufficient process description to reliably partition chemical movement between surface and sub-surface pathways and to account for in situ decay. It provides a mass balance of water and can therefore predict in the long term (i.e., several years) as well as on an event basis. The model allows for an accurate representation of agricultural systems and therefore can be used to predict the relative effect of changing farm practice.

- existing information on the effects of various conservation farming systems on runoff process parameters is not sufficient to allow for quantitative assessments of benefit. Relatively few case studies have been conducted which aimed at defining runoff parameter sensitivity. More site specific field and plot level studies in the Ontario agricultural setting are necessary to define these relationships.

- the most promising and practical conservation management practices which were examined in this study for the control of soil erosion and associated phosphorus and atrazine loss were the no till or zero till system and strip contour cropping. The no till system was effective by providing soil cover against rainfall impact and in reducing surface runoff. The strip contour system was effective by providing grass strips which intercept overland flow and filter out the soil particles. In addition, contour plowing reduces overland runoff and gully erosion. Both of these systems displayed promising potential for soil chemical control.

  The optimization of atrazine application system was significantly effective in reducing atrazine loss but may be somewhat impractical as it requires a reliable long term weather forecast of several days which cannot be provided in many areas. Nevertheless, this scheme requires no cost to implement and it does not necessitate changes in land management practice and therefore it should be considered in conjunction with other schemes.

  The structural measures examined here (i.e., tile drainage and retention basins) may have limited use for localized problems but cannot be considered for widespread application as a conservation scheme.

  The incorporation of fertilizer and pesticides into the soil matrix were not particularly effective in this analysis. Incorporation would be more effective in reducing losses of strongly soil bound material.

- HSPF is a substantial model requiring application by experts. HSPF modelling exercises should not be undertaken without sufficient computing resources, time, clearly defined objectives and a well developed database. Simpler, more generalized models are available for the screening of land management options and for the identification of erosion prone areas. These are recommended in cases where calibration databases do not exist or when objectives are less demanding. HSPF should be utilized in assessments which require quantitative evaluations of whole watershed processes including subsurface drainage and pesticide considerations.

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APPENDIX A

MOE FIELD LEVEL ATRAZINE DECAY STUDIES

TEST PLOT STUDIES OF
ATRAZINE DECAY RATES FROM SOILS
IN THE
NISSOURI CREEK AGRICULTURAL WATERSHED

Prepared by

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April 1987

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SUMMARY

As part of a 3 year comprehensive data collection and model development study to "Model The Environmental Fate of Soil, Nutrients, and the Herbicide Atrazine in an Agricultural Watershed", the Water Resources Branch of the Ontario Ministry of Environment conducted on-farm studies to determine the environmental decay rate of atrazine from soils. Field surveys were carried out in 1985 and 1986 on working farms located within the major representative soil types in the Missouri Creek Watershed. Data from the soil decay studies will support the model calibration.

Atrazine levels in the soil were found to decline exponentially following the equation $\text{Log } Y = a + b X$, where Y is the herbicide residue in soil, and X the time in days elapsed since application. Half-life dissipation varied from 46 days in the 1985 survey for the 0-2 cm profile of an Embro Silt Loam soil following a post-emergent atrazine application, to 95 days for the 0-5 cm profile of a Guelph Loam soil following a pre-plant application during the 1986 survey. Following application, atrazine was observed to increase in concentration at lower depths in the plough layer of the soil, however the residue values were small, less than 10% of surfical values as observed at 60 days after application.

ACKNOWLEDGEMENTS

This study was carried out under the general supervision of Dr. Lloyd Logan whose commments and editorial assistance are gratefully acknowledged.

The on-farm data collection undertaken for this study would not have been possible without the co-operation of the participating farmers. Mr. Richard Hiscocks allowed us to establish the first test plot in 1985 on his property at Concession II, Lot 15 of the Township of Zorra. In 1986, Mr. Lloyd Ball supported the survey on his farm at Concession I, Lot 13 of the Township of Zorra. For their co-operation and courtesy we are sincerely grateful.

Dr. Brian Ripley and Mr. Steve Clegg at the Ontario Ministry of Agriculture and Food's Pesticide Residue Laboratory at Guelph, gave support with sampling methodolgy, laboratory analysis, and interpretation of analytical results.

Thanks also to Keith Willson of the Water Resources Branch, and students Susan Hanff and Kevin French for providing field assistance.

INTRODUCTION

Modelling Study Background

Recent concern over the environmental fate and related hazards of agricultural chemicals as well as concern over long term soil losses and associated stream nutrient enrichment, have stimulated interest in the use of hydrological and water quality models as predicitive management tools. In 1985, Beak Consultants Limited were chosen to conduct a three year comprehensive data collection and model development study in an agricultural watershed on behalf of the Ontario Ministry of the Environment. The Nissouri Creek watershed, located in Oxford County in southwestern Ontario, was designated as the pilot study watershed.

The study was designed to provide field data for use with the HSP-F Model(Hydrological Simulation Program Fortran) to predict runoff losses of the herbicide atrazine and its effect on stream water quality.

The overall study objectives included the following:

- collect data on hydrology, water quality, watershed characteristics, soil types, atrazine characteristics, and current agricultural management practices in a pilot watershed study, to support mathematical modelling activities;

- calibrate a comprehensive land management model (HSP-F) and simulate watershed hydrology, soil loss, phosphorus and atrazine transport from the watershed;

- evaluate the effectiveness and practicality of using watershed modelling to predict soil losses and the environmental fate of nutrients, and pesticdes; and

- recommend appropriate land management practices, remedial measures, and guidelines for reducing the loss of soil and atrazine to surface water.

Field Surveys of Atrazine Decay in Nissouri Soils

In support of the overall modelling efforts carried out by Beak Consultants Limited, the Water Resources Branch agreed to carry out on-farm surveys to determine the environmental decay rate of atrazine in soil types of the Nissouri Creek study watershed.

Because literature evidence and modelling studies with HSP-F suggest that most of the atrazine applied to the fields never leaves with overland or subsurface runoff, but rather decays insitu; one of the critical parameters to assist model calibration is the decay rate of atrazine. Past modelling efforts have viewed the mass of atrazine which comes in contact with rainfall as being from the top few millimeters of soil. Accordingly, these studies have used the mass of atrazine applied, rainfall patterns, runoff rates, pesticides decay rates; and empirical constants for relating pesticide movement between the top soil layer and the rainfall-runoff pattern to describe the export of atrazine. Generally observations on soil concentrations over time have not been used.

Frank and Sirons (1985) have reported on the decline of atrazine based on a wide range of soils collected from a large number of locations across Ontario. The data, collected between 1970 and 1980, included experimental as well as commercial farms. They determined that atrazine residues declined exponetially following the general equation

Log Y = a + bX, where Y is the herbicide residue in the upper 0-6 cm of soil, and X the time that had elapsed following application. They have concluded that dissipation of atrazine ranged from 2.4 to 3 months.

Confirmation of similar empirical equations for soils of the Nissouri watershed was key to model calibration. Therefore, studies were undertaken in the Nissouri Creek Pilot Agricultural Watershed in 1985 and 1986, to collect experimental data on atrazine decay with the folowing objectives:

- carry out surveys of actual field application of the herbicide atrazine on commercial farms located within the boundaries of the study basin;
- measure and derive the environmental decay rate of atrazine and its derivatives in soil on test plots located within fields representative of the major soil types; and
- montitor the time dependant vertical migration of atrazine and its derivatives in the plough layer of soil.

Atrazine Agricultural Herbicide

The subject of the present study is the herbicide 2 Chloro-4-ethylamino-6-isopropylamino-s-triazine which is commercially known as atrazine. Atrazine is one member of the 25 member triazine herbicide group whose members are, with few exceptions, based on a s-triazine aromatic ring structure.

Atrazine is sparingly soluble in water, 33 ppm at 25°C, has a low vapor pressure, 3×10^{-7} mm Hg at 20°C, and is a solid under normal environmental conditions. Toxicological studies using rats have shown moderate LD_{50} values of approximately 3080 mg/kg of body weight, and acute 96 Hour LC_{50} toxicities using rainbow trout of 4.5 mg/l (Agriculture Canada 1982).

Atrazine was introduced into Ontario agriculture in 1960 as a selective herbicide for the control of annual broadleaf and grassey weeds in field corn. It controls most annual weeds and at higher rates of application eliminates several perennial species. Field corn production can be maintained for several successive years with appropriate application of fertilizer and atrazine.

Atrazine is the most widely used herbicide in field corn production in Ontario. On field crops in the Province in 1983, McGee (1984) reported the herbicides used in largest quantities were atrazine (1720 tonnes); alachlor (1056 tonnes); metolachlor (826 tonnes); and cyanazine 420 tonnes). Typically, throughout southwestern Ontario, atrazine is not applied alone, but is applied in a tank mixture with other herbicides such as metolachlor and dicamba, to provide a broad spectrum of weed control.

Atrazine is applied in the spring, shortly before or shortly after planting of corn. It may be applied before planting with subsequent incorporation into the soil, or pre- or post emergence of the corn crop. More recently, manufacturers have been recommending a split treatment (fall & spring) as the most effective an economical means of achieving extended weed control. For continuous corn monoculture, atrazine is typically applied at rates of 2.2 kg/ha or more. In soil, approximately 10% of the total atrazine residue is often carried over to the next growing season, and this residue may result in damage to susceptable crops. When rotating to another crop Frank et al (1985) have recommended application rates of less than or equal to 1.1 kg/ha. At this rate, twelve months after application atrazine residues are below 0.10 ug/g, and soils can safely be planted to susceptable crops.

Study Watershed

The Nissouri Creek basin selected as the pilot study watershed, lies completely within Oxford County in Southwestern Ontario approximately 15 km northwest of the City of Woodstock. The location of the watershed is illustrated on the areal map of Southwestern Ontario in Figure 1. The watershed is about 30 square km in area and contains about 55 active farms.

The Nissouri Creek Agricultural Watershed was one of eleven agricultural basins studied from 1975 to 1977 under the Pollution from Land Use Activities Reference Group (PLUARG). The existence of a historical data base and the watershed's relatively homogeneous land use and physical geography make it an ideal subject for this type of study. PLUARG studies (Wall et al, 1975) found the Nissouiri watershed to be representative of about 990 square Km in Southern Ontario.

The creek drains from a gently rolling portion of the Oxford Till Plain, joining the Middle Thames River just upstream of the Town of Thamesford. A low topographic relief and low permeability of the subsurface soils makes this area a prime site for agricultural tile drainage, and the cultivated acreage of the area is almost entirely serviced with subsuface tile drainage systems.

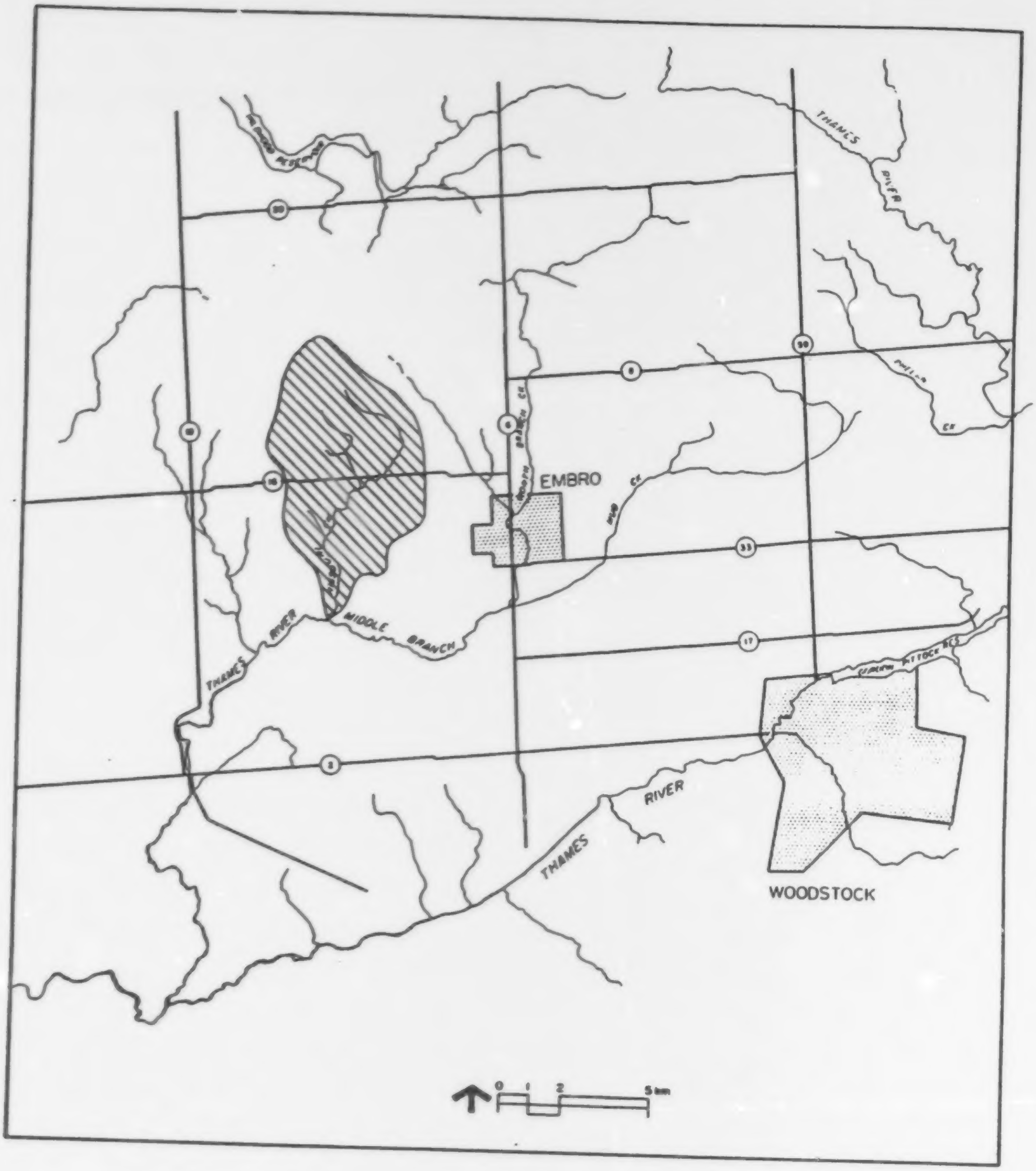

THAMES RIVER
EMBRO
MIDDLE BRANCH
THAMES RIVER
THAMES RIVER
WOODSTOCK
0 1 2 5 km

FIGURE 1

Location of the Nissouri Watershed in Southwestern Ontario

▨ NISSOURI WATERSHED

Seven soil types are found in the Nissouri Watershed and are listed in Table 1. The Guelph Loam and the Embro Silt Loam are by far the most predominant soil types covering 45% and 36% of the watershed respectively, and together reprsenting 81% of the basin area. Most of the watershed is rated as Class 1 agricultural land due to the exellent soils. Figure 2 shows the distribution of the soil types in the watershed.

A 1985 survey of the basin found 50% of the land in corn, with a further 30% in hay, cereals, vegetables and fruits. The remaining area was either forested, in pasture or taken up by roads and residences.

Table 1 SOIL TYPES IN THE NISSOURI WATERSHED

Soil Type	Description	Area Covered (Hectares)	% of Watershed
Guelph Loam	- calcareous loam till with good drainage & steep to rolling topography	1395	44.6
Embro Silt Loam	- silty alluvial deposits over calcareous loam till, imperfect drainage gently sloping topography	1125	35.9
Honeywood-Guelph Complex	- mixed silty deposits, good drainage, smooth to rolling topography	370	11.8
Tavistock Silt Loam	- silty deposits over clay & clay loam till, imperfect drainage, gently sloping	92	2.9
Muck	- deep organic deposits very poor drainage	68	2.2
Bottom Land	- recent alluvium with vaiable drainage	60	1.9
Parkhill Loam	- calcareous loam till with poor drainage, level topography	20	0.7

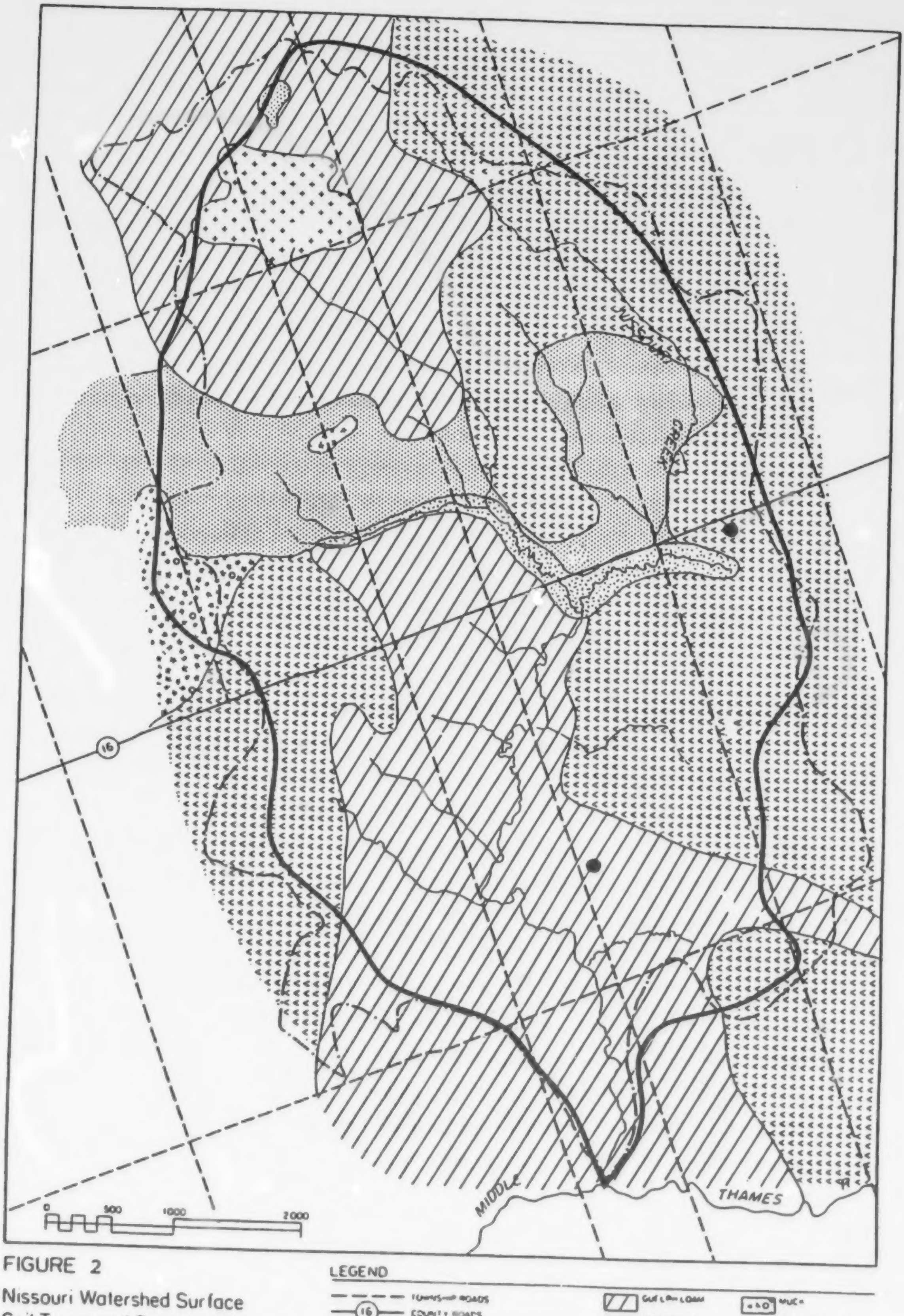

CREEK
16
MIDDLE
THAMES
0
500
1000
2000
LEGEND
TOWNSHIP ROADS
COUNTY ROADS
SUBSURFACE WATERSHED BOUNDARIES
SURFACE WATERSHED BOUNDARY
SOIL SAMPLING SITES
GUELPH LOAM
EMBRO SILT LOAM
HONEYWOOD-GUELPH COMPLEX
TAVISTOCK SILT LOAM
MUCK
BOTTOM LAND
PARKHILL LOAM

FIGURE 2

Nissouri Watershed Surface Soil Types and Sampling Sites

METHODS AND MATERIALS

Field studies to directly monitor the environmental decay rates of atrazine on farms in the Nissouri Creek pilot watershed were undertaken during the 1985 and 1986 corn crop seasons. The surveys were designed to monitor atrazine concentrations under practices and conditions existing on actual working farms within the watershed. Selection of farm locations was primarily directed by the desire to study atrazine decay rates in the two main soil types of the watershed, - the Embro Silt Loam and the Guelph Loam series.

1985 Test Plot Survey

Survey Field - Embro Silt Loam

In May 1985, a study site was selected on a farm property at Concession II, Lot 15, Township of Zorra. The surface soils of the farm are predominantly the Embro Silt Loam Series, a silty clay, black in colour, with imperfect drainage, and neutral pH. The cultivation layer is about 30 cm thick and is underlain by a brown calcareous till of poor drainage. The farm fields are serviced by systematic tile drains (10 cm diameter plastic pipe on 15 Meter centres). The 10 cm field tiles discharge to a 60 cm diameter covered municipal drain which bisects the farm and in turn discharges to the Nissouri Creek approximately 100 Meters south of Oxford County Road 16. Corn is grown on the farm to provide feed for a pig rearing operation.

A test plot site 50 meters by 10 meters was established at the north side of the field adjacent to Oxford County Road 16 prior to the 1985 atrazine application. Corn was seeded on row spacing of 75 cm (30 in) by the farmer on May 15 1985. This seeding was followed by pre-emergent herbicide application tank mixture containing metolachlor and dicamba.

Atrazine Application

On May 30, 1985, a post emergent application of atrazine, formulated to give an application rate of 2 kg/ha, was made to the field using a tractor drawn sprayer with 10.5 meter boom fitted with broadcast spray nozzles at 40 cm centres. The tank mixture of 20 kg of Ciba Geigy AATREX NINE-O (85.5% active ingredient), water dispersible granules in 2275 litres (500 gallons) of water was applied with the tractor travelling at 8 km/h and the sprayer delivering at the rate of 235 l/ha.

Prior to application, the sprayer nozzle delivery rate was confirmed using an Ontario Ministry of Agriculture and Food (OMAF) Sprayer Calibration Bottle on a selection of nozzles. Application of atrazine onto the soil of the test plot was directly monitored by using Whatman #1 9 cm diameter filter discs placed in glass petrie dishes on the ground to intercept the liquid spray. A total of 15 filter discs were positioned diagonally across the plot in groups of 5 replicates under the left, centre, and right sections of the sprayer boom. Following spraying, the petrie dishes with filter discs were sealed in individual sample bags, and delivered to the laboratory for analysis.

Soil Sample Collection

In the weeks following application, soil samples from the test plot were collected at 3 depths, surface 0-2 cm, 12-18 cm, and 30-35 cm, using an Oakfield split core soil sampler. Samples were collected at gradually lengthening time intervals, beginning at 5 day intervals for the first 30 days, lengthening to every 7 days for the next 60 days, and finally to every 15 days for the next 90 days after which the ground became frozen. Soil samples, composited from several locations across the test plot were collected in triplicate sets, stored in amber wide mouth glass jars, and kept refrigerated until submission for analysis.

1986 Test Plot Survey

Survey Field - Guelph Loam

In early 1986, a second study site was established at a farm at Concession I, Lot 13, in the Township of Zorra. The soils of this farm are predominantly of the Guelph Loam Series, a loam till, which is dark gray in colour, with good drainage and neutral pH. The cultivation layer in this field is approximately 40 cm thick and is underlain by a brown calcareous till of poor natural drainage. The field is serviced with subsurface systematic tile drainage (clay tile on 15 M centres). Corn is grown on the farm support a beef feedlot operation.

A test plot site of 50 meters by 10 meters was established at the west side of the field in early May following spring cultivation for the 1986 crop season.

Atrazine Application

On May 12 1986, a pre-plant application of atrazine, formulated to give an application rate of 1.2 kg/ha, was made by the farmer using a tractor drawn sprayer with 8.5 meter boom fitted with broadcast spray nozzles at 45 cm centres. The tank mixture of 15 litres of Chipman ATRAZINE Flowable liquid (451 gm/l active ingredient) in 1360 litres (300 gallons) of water was applied with the tractor travelling at 8 km/h and the sprayer delivering at the rate of 258 l/ha. The field sprayer and application are shown in photos B1 and B2 of Appendix B. In addition to atrazine, the tank mixture also included 15 litres of the herbicide metolachlor.

Prior to application, the sprayer nozzle delivery rates were confirmed using an OMAF sprayer calibration bottle on a selection of nozzles. As in the previous year's survey, the application of atrazine onto the soil of the test plot was directly monitored using Whatman #1 9 cm diameter filter discs placed in glass petrie dishes on the ground to intercept the liquid spray. Fifteen filter papers were positioned diagonally across the plot in groups of 5 replicates under the left, centre and right sections of the sprayer boom. Following application, the petrie dishes with filter discs were sealed in sample bags, and delivered to the laboratory for analysis.

After spraying, the farm operator incorporated the herbicide into the top 5 cm of the soil using a tractor drawn soil mulcher. Finally corn was seeded into the soil.

Soil Sample Collection

For the 1986 application, soil samples from the test plot were collected at 2 depths, surface 0-5 cm, and depth 30-35 cm, using an Oakfield split core soil sampler. As there was little difference in residue levels at the 12-18 and 30-35 cm depths in the 1985 survey the mid-depth sampling was discontinued in 1986. In 1986, surface sampling depth was increased to 5 cm depth from 2 cm in 1985. Increasing the surface sample core to 5 cm ensured a more uniform sampling of the surface zone in which the herbicide was incorporated.

As with the 1985 program, samples were collected at gradually lengthening time intervals, beginning at every 5 to 7 days for the first 60 days, reducing to every 15 days for the next 60 days, and finally to every 30 days for the next 100 days, after which time the ground became frozen. Soil samples, composited from several locations across the test plot were collected in triplicate sets, stored in amber wide mouth glass jars (Photo B3), and kept refrigerated until submission for analysis.

LABORATORY ANALYSIS

All analyses for atrazine residues were performed by the Ontario Ministry of Agriculture and Food's Agricultural Laboratory Services, Pesticides Residue Section. The analytical procedure described by Frank et al (1973) was used for the extraction of atrazine and its metabolite de-ethylatrazine. Qualitative and quantitative analyses were determined by gas-liquid chromotography.

RESULTS AND DISCUSSION

Atrazine Application Monitoring

Direct monitoring of pesticide application using filter discs to intercept liquid spray at the soil surface provided a means to confirm the uniformity of pesticide delivery from the sprayer over the test plot; as well as a measure of the amount of pesticide actually reaching the ground.

Atrazine concentrations on the filter discs (Table 2) positioned under the left, centre, and right boom sections of the field sprayer were uniform, confirming generally consistent pesticde delivery over the test plots.

TABLE 2 Atrazine on Filter Discs
(Average Concentration (ug/disc))

Year	Location Under Field Sprayer Boom		
	Left	Centre	Right
1985	670	650	630
1986	295	240	280

The reduced atrazine level measured under the centre boom during the 1986 survey might have resulted from the difficulties with proper positioning of the filter discs in the area travelled by the tires of the tractor and field sprayer.

In the 1985 survey, the farmer prepared a tank mixture for an application rate of 2.06 kg/ha of total product and 1.76 kg/ha of active ingredient atrazine. At this application rate, a 9 cm diameter filter paper could capture 1125 ug of atrazine. Average atrazine concentration measured on the filter discs of 650 ug, represents about 58 % of expected. Similarly, the 1986 tank mixture was prepared for an application rate of 1.28 kg/ha or 815 ug per 9 cm diameter filter paper. Average atrazine concentration on the 1986 filter discs was 280 ug, or 33% of expected.

While the operators applied the pesticide in the early part of the day in an effort to avoid wind drift, during both surveys, light winds were present resulting in some drift of the spray. Ritcey et al (1981) have reported that volatilisation also represents an important avenue of loss during application, with extensive losses from volatilization for pesticides with vapor pressure less than 10^{-4} mmHg at 20°C. While atrazine has a vapor pressure of 3×10^{-3}, with farm field sprayer booms typically at some 75 cm above bare ground and light winds, there is considerable potential for loss from both volatilization and wind drift.

Soil Residue Monitoring

The results of individual analyses for atrazine, and it's metabolite de-ethylatrazine, for all soil samples collected from the test plots are provided in Tables A1 and A2 of Appendix A. Results for the triplicate samples taken at each time interval were within the range normally expected for farm field soil sampling. A mean of the concentrations reported for the indivdual triplicate samples has been taken as the reporting value. A summary of the total atrazine concentrations for the monitoring surveys is given in Tables 3 and 4.

TABLE 3 Residues of Atrazine in Soil in 1985 (Application Rate 1.76 Kg/Ha Active Ingredient)

Sample Collected		Days Since	Concentration in ug/g Sampling Depth		
Month	Day	Applic.	0-2 cm	12-18 cm	30-35 cm
May	30	1	19.30	0.11	0.03
June	5	6	13.10	0.06	0.11
June	10	11	8.10	0.09	0.11
June	14	15	6.42	0.08	0.09
June	19	20	3.33	0.14	0.08
June	24	25	3.43	0.09	0.03
June	28	29	7.04	0.15	0.06
July	3	34	4.52	0.15	0.11
July	8	39	8.43	0.15	0.07
July	17	48	4.01	0.11	0.02
July	24	55	5.94	0.13	0.09
August	1	63	5.27	0.10	0.08
August	14	76	2.74	0.12	0.06
August	21	83	3.22	0.08	0.04
August	28	90	3.88	0.08	0.08
Sept	11	104	3.24	0.14	0.03
Sept	25	118	1.58	0.16	0.03
October	7	130	1.76	0.09	0.04
October	23	146	1.47	0.15	0.06
November	7	161	0.87	0.08	0.06
November	20	174	0.55	0.06	0.03
December	13	197	0.45	0.06	0.03

TABLE 4 Residues of Atrazine in Soil in 1986 (Application Rate 1.28 Kg/Ha Active Ingredient)

Sample Collected		Days Since	Concentration in ug/g Sampling Depth	
Month	Day	Applic.	0-5 cm	30-35 cm
May	13	1	1.23	0.05
May	16	4	1.36	0.05
May	21	9	1.11	0.08
May	26	14	0.98	0.05
May	30	18	1.29	0.05
June	3	22	1.16	0.08
June	10	29	1.56	0.07
June	18	37	1.43	0.08
June	26	45	1.25	0.05
July	9	58	0.79	0.07
July	23	72	0.80	0.04
August	6	86	0.70	0.07
August	20	100	0.65	0.05
Sept	18	129	0.41	0.04
October	8	149	0.58	0.03
November	5	177	0.27	0.06
December	17	219	0.36	0.04
April	3	326	0.19	0.02

The 1985 survey monitored the atrazine decay in the upper 0-2 cm layer following a 1.76 kg/ha post-emergent application on soil of the Embro Silt Loam Series. Figures 3 and 4 show the changes in atrazine residue with time following application. Following a rapid breakdown of the herbicide in the first 20 days after application, some increase in concentration was observed in the period from 21 to 60 days (Figure 3). The short term rise in concentration may be the result of a 'wicking effect' during July and August as the warm dry soil at the surface drew moisture from depth. Over the 8 month period, from application in May to freezing of the soil in late December, the atrazine levels declined exponentially following the general equation Log Y = a + bX, where, Y is the herbicide residue in the soil, and X the time in days since application. The calculated half-life of atrazine for the survey data (Table 5) is 46 days.

Table 5 Decay of Atrazine in Soils of Embro Silt Loam Series

Application Rate Kg/Ha	Months of Sample Data	Regression Equation	Half Life (Days)
1.76	8	Log Y = 1.007 - .0065 X r = -0.93 F = 123.8	46

Atrazine was consistently detected in samples taken at lower depths of 12-18 cm and 30-35 cm (Figure 4), however residue values were small, less than 10% of the concentrations observed in the upper 0-2 cm horizon at 60 days after application.

The 1986 survey monitored atrazine decay in the upper 0-5 cm soil layer following a 1.28 kg/ha pre-plant incorporated application on soil of the Guelph Loam Series. General behaviour of atrazine soil residues with time at surface and depth (Figures 5 & 6) was consistent with that observed in the previous years survey. An additional set of soil samples were collected in early spring of the following year as soon as the ground thawed. This allowed assessment of the effect of colder winter and early spring temperatures on half-life disappearance.

The calculated half-life disappearance for the initial 8 month period (Table 6) is 95 days. Inclusion of the post winter sample data in the calculation extends the calculated half-life (Table 6) to 105 days. The more rapid breakdown of the herbicide in the initial summer-fall period is probably attributable to warmer soil temperatures.

Table 6 Decay of Atrazine in Soils of Guelph Loam Series

Application Rate Kg/Ha	Months of Sample Data	Regression Equation	Half Life (Days)
1.28	8	$\text{Log } Y = 0.141 - .0032\,X$ $r = -0.92$ $F = 81.2$	95
1.28	12*	$\text{Log } Y = 0.125 - .0028\,X$ $r = -0.94$ $F = 120$	105

* includes post-winter sample

Fig. 3 ATRAZINE RESIDUE —EMBRO SILT LOAM

Surface Samples 0–2 cm

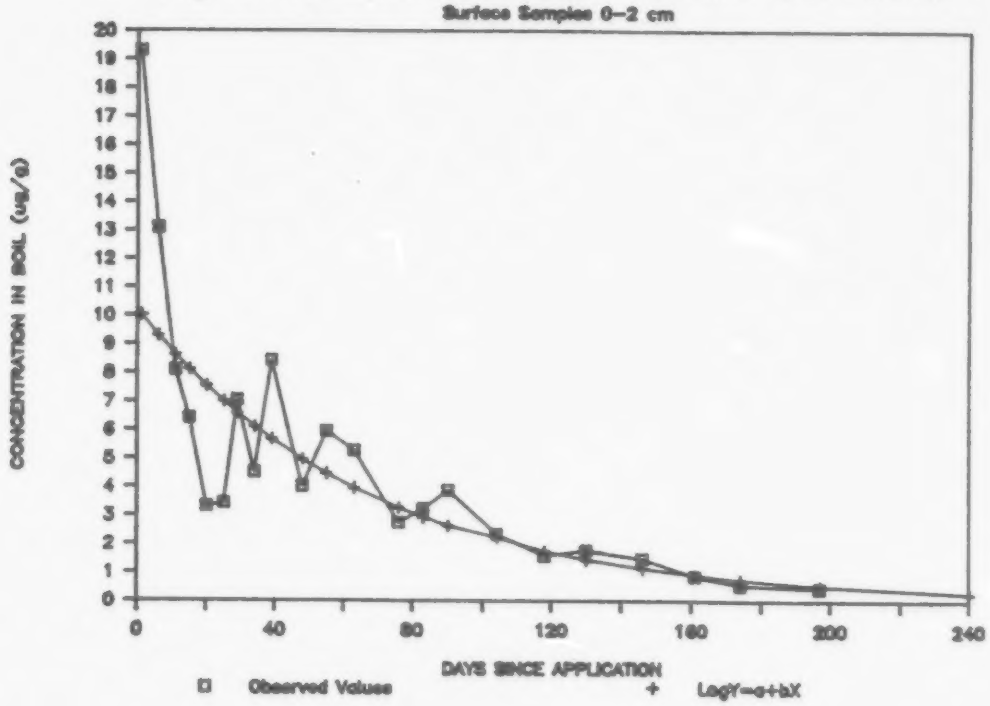


Fig 4 ATRAZINE RESIDUE —EMBRO SILT LOAM

Samples at Depth

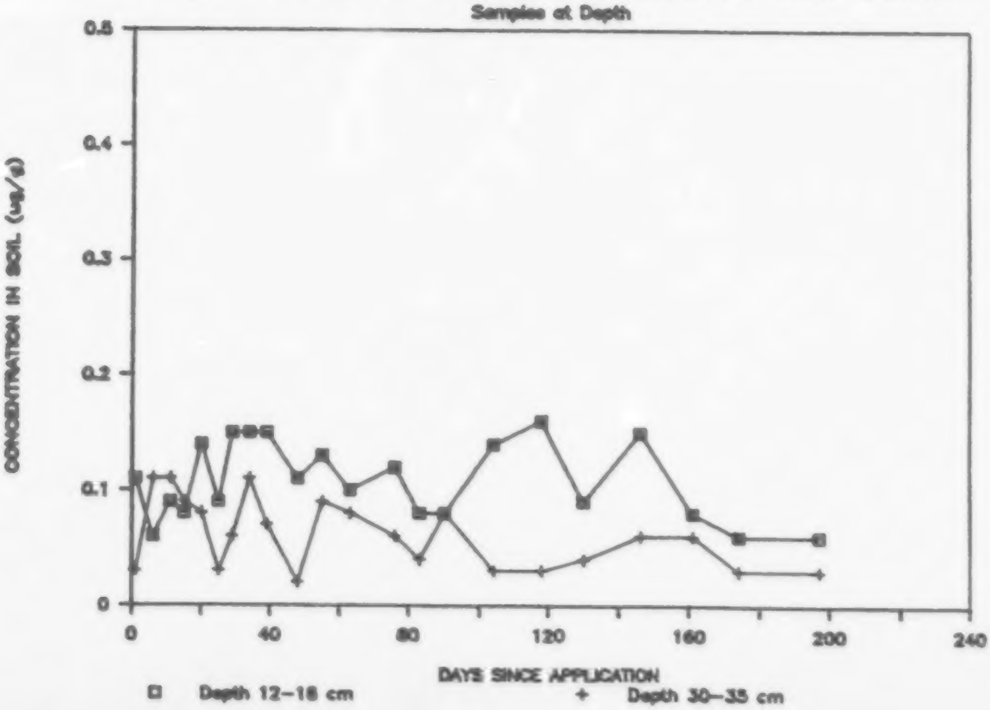


Fig. 5 ATRAZINE RESIDUE – GUELPH LOAM

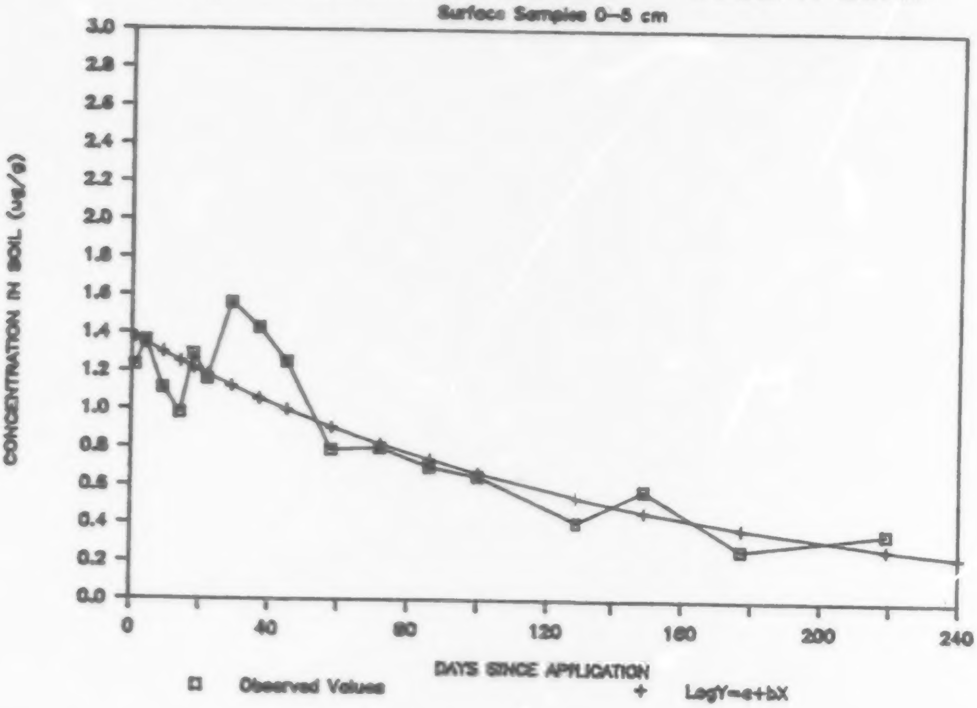
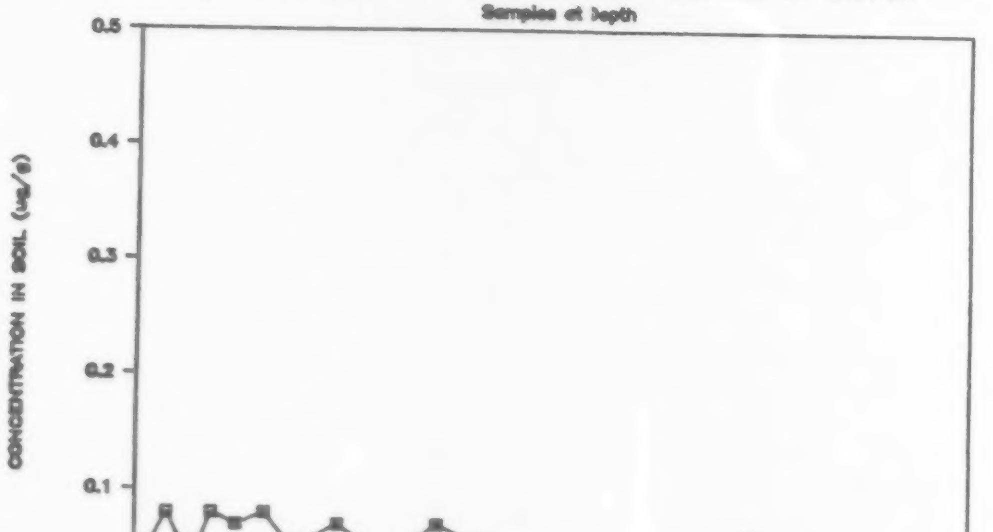


Fig. 6 ATRAZINE RESIDUE – GUELPH LOAM



Frank and Siron's (1985) investigations on a wide range of Ontario soils, found half-life disappearance of atrazine ranging from 2.4 to 3 months (72 to 90 days). The results of the 1985 survey on an Embro Silt Loam shows a comparatively shorter half-life of 46 days. This difference in environmental decay rate could have been due to the post-emergent application technique and the shallow (0-2 cm) suface soil sampling techniques used. These factors could have contributed to a more rapid loss of atrazine at the soil surface because of exposure to wind, sun, and surface runoff.

CONCLUSIONS

Successful field decay studies for the herbicide atrazine were carried out to support the watershed modelling study in the Nissouri Creek watershed to complete prediction of the environmental fate and transport of soils, nutrients, and herbicides.

Decline of atrazine residues in the soils of the Nissouri Creek watershed conformed to the exponential relation $\text{Log } Y = a + bX$ defined in the literature for Ontario soils.

Varying decay rates were observed in the two major soil types of the watershed ranging from 46 days for the 0-2 cm profile of an Embro Silt Loam soil following a post-emergent application, to 95 days for the 0-5 cm profile of a Guelph Loam soil following a pre-plant application.

At lower depths in the plough layer (30-35cm) atrazine was observed in the period following application, however residue levels were small, less than 10% of surficial concentration as observed at 60 days after application.

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APPENDIX A

Soil Sample Data - Atrazine Residue

TABLE A1 RESIDUES OF ATRAZINE IN SOIL SAMPLES 1985

Application Rate of 1.76 Kg/Ha
ANALYTICAL RESULTS FROM OMAF PESTICIDES RESIDUE LABORATORY
Concentration in ug/gm.

Depth (cm)	MAY 31 Atrazine	MAY 31 De-ethyl Atrazine	JUNE 5 Atrazine	JUNE 5 De-ethyl Atrazine	JUNE 10 Atrazine	JUNE 10 De-ethyl Atrazine	JUNE 14 Atrazine	JUNE 14 De-ethyl Atrazine	JUNE 19 Atrazine	JUNE 19 De-ethyl Atrazine
0-2	18.0	ND	9.3	ND	8.0	ND	5.5	0.57	4.2	0.29
0-2	18.0	ND	17.0	ND	12.0	ND	5.6	0.62	2.5	0.19
0-2	22.0	ND	13.0	ND	4.2	ND	6.2	0.66	2.6	0.22
Mean	19.3	0.00	13.1	0.00	8.1	0.00	5.8	0.62	3.1	0.23
(cm)										
15	0.15	ND	0.06	ND	0.07	ND	0.08	0.02	0.09	0.03
15	0.04	ND	0.07	ND	0.08	ND	0.08	0.03	0.11	0.05
15	0.13	ND	0.15	ND	0.11	ND	0.07	0.02	0.12	0.03
Mean	0.11	0.00	0.09	0.00	0.09	0.00	0.08	0.02	0.11	0.04
(cm)										
30	0.05	ND	0.05	ND	0.10	ND	0.07	ND	0.05	0.03
30	0.02	ND	0.08	ND	0.07	ND	0.11	ND	0.06	0.02
30	0.03	ND	0.10	ND	0.16	ND	0.10	0.04	0.03	0.03
Mean	0.03	0.00	0.08	0.00	0.11	0.00	0.09	0.00	0.05	0.03

Depth (cm)	JUNE 24 Atrazine	JUNE 24 De-ethyl Atrazine	JUNE 28 Atrazine	JUNE 28 De-ethyl Atrazine	JULY 3 Atrazine	JULY 3 De-ethyl Atrazine	JULY 8 Atrazine	JULY 8 De-ethyl Atrazine	JULY 17 Atrazine	JULY 17 De-ethyl Atrazine
0-2	2.2	0.16	8.2	0.67	3.80	0.68	8.0	0.88	4.1	0.50
0-2	3.7	0.25	5.3	0.52	3.90	0.42	7.4	0.77	4.3	0.45
0-2	3.8	0.29	5.7	0.74	4.30	0.46	7.4	0.85	2.3	0.27
Mean	3.2	0.23	6.4	0.64	4.00	0.52	7.6	0.83	3.6	0.41
(cm)										
15	0.11	0.04	0.12	0.00	0.10	0.04	0.14	0.07	0.07	0.04
15	0.08	0.03	0.45	0.10	0.12	0.06	0.23	0.09	0.15	0.05
15	0.07	0.03	0.18	0.07	0.13	0.08	0.08	0.06	0.11	0.05
Mean	0.09	0.03	0.25	0.06	0.12	0.06	0.15	0.07	0.11	0.05
(cm)										
30	0.03	ND	0.070	ND	0.23	0.05	0.06	ND	0.03	ND
30	0.02	ND	0.070	ND	0.07	ND	0.06	ND	0.01	ND
30	0.03	ND	0.050	ND	0.10	0.03	0.08	ND	0.02	ND
Mean	0.03	0.00	0.063	0.00	0.13	0.03	0.07	0.00	0.02	0.00

TABLE A1 Continued

Depth (cm)	JULY 24		AUGUST 1		AUGUST 14		AUGUST 21		AUGUST 28	
	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine
0-2	6.6	0.78	4.4	0.60	2.1	0.28	3.0	0.29	4.7	0.36
0-2	6.2	0.75	4.7	0.74	3.3	0.45	2.7	0.34	2.9	0.26
0-2	3.2	0.39	4.8	0.68	1.9	0.29	3.0	0.32	3.1	0.21
Mean	5.3	0.64	4.6	0.67	2.4	0.34	2.9	0.32	3.6	0.28
(cm)										
15	0.09	0.05	0.17	0.11	0.07	0.05	0.07	0.02	0.07	0.05
15	ND	0.07	0.34	0.10	0.07	0.05	0.06	0.02	0.04	0.02
15	ND	0.09	0.29	0.06	0.15	0.06	0.06	0.02	0.08	0.05
Mean	0.03	0.07	0.26	0.09	0.10	0.05	0.06	0.02	0.06	0.04
(cm)										
30	0.05	0.03	0.07	ND	0.05	0.02	0.02	0.01	0.05	0.02
30	0.06	0.05	0.07	ND	0.03	0.02	0.02	0.02	0.07	0.03
30	0.05	0.04	0.09	0.04	0.05	0.02	0.03	0.02	0.06	0.02
Mean	0.05	0.04	0.07	0.01	0.04	0.02	0.02	0.02	0.06	0.02

Depth (cm)	SEPTEMBER 11		SEPTEMBER 25		OCTOBER 7		OCTOBER 23		NOVEMBER 7	
	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine
0-2	2.0	0.24	1.3	0.29	1.3	0.40	1.20	0.48	0.59	0.25
0-2	1.6	0.23	1.2	0.26	1.5	0.37	1.10	0.42	0.56	0.22
0-2	2.6	0.26	1.3	0.30	1.3	0.31	0.88	0.34	0.70	0.27
Mean	2.1	0.24	1.3	0.28	1.4	0.36	1.06	0.41	0.62	0.25
(cm)										
15	0.11	0.04	0.13	0.06	0.07	0.05	0.14	0.18	0.05	0.04
15	0.15	0.07	0.18	0.12	0.08	0.06	0.09	0.10	0.07	0.08
15	0.59	0.19	0.11	0.08	0.09	0.04	0.56	0.09	0.03	0.04
Mean	0.28	0.10	0.140	0.087	0.08	0.05	0.26	0.12	0.05	0.05
(cm)										
30	0.02	0.01	0.01	0.01	0.02	0.01	0.04	0.06	0.04	ND
30	0.02	0.02	0.01	0.01	0.05	0.02	0.02	ND	0.04	0.06
30	0.01	ND	0.02	0.03	0.02	ND	0.03	0.04	0.02	0.02
Mean	0.017	0.010	0.013	0.017	0.030	0.010	0.030	0.033	0.03	0.03

TABLE A1 Continued

	NOVEMBER 20		DECEMBER 13	
Depth (cm)	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine
0-2	0.51	0.20	0.43	0.10
0-2	0.40	0.15	0.32	0.05
0-2	0.30	0.10	0.35	0.08
Mean	0.40	0.15	0.37	0.08
(cm)				
15	0.04	0.03	0.05	0.04
15	0.07	0.05	0.05	0.04
15	0.04	0.02	0.04	0.04
Mean	0.05	0.03	0.05	0.04
(cm)				
30	0.02	0.02	0.01	ND
30	0.02	0.02	0.02	0.02
30	0.02	ND	0.02	0.02
Mean	0.02	0.01	0.02	0.01

TABLE A2 RESIDUES OF ATRAZINE IN SOIL SAMPLES 1986

Application Rate of 1.28 Kg/Ha
ANALYTICAL RESULTS FROM OMAF PESTICDES LABORATORY
Concentration in ug/gm.

Depth (cm)	MAY 7 Atrazine	MAY 7 De-ethyl Atrazine	MAY 13 Atrazine	MAY 13 De-ethyl Atrazine	MAY 16 Atrazine	MAY 16 De-ethyl Atrazine	MAY 21 Atrazine	MAY 21 De-ethyl Atrazine	MAY 26 Atrazine	MAY 26 De-ethyl Atrazine
0-5	0.02	0.02	1.50	0.05	1.20	0.08	0.82	0.12	0.87	0.19
0-5	0.02	0.01	0.95	0.04	1.20	0.09	1.00	0.15	0.72	0.19
0-5	0.02	0.01	1.10	0.05	1.40	0.10	1.10	0.14	0.81	0.15
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.02	0.01	1.18	0.05	1.27	0.09	0.97	0.14	0.80	0.18
(cm)										
30	ND	ND	0.03	0.02	0.02	0.02	0.06	0.03	0.02	0.02
30	ND	ND	0.02	0.01	0.02	0.02	0.04	0.03	0.02	0.02
30	ND	ND	0.03	0.02	0.05	0.02	0.04	0.03	0.03	0.04
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.00	0.00	0.03	0.02	0.03	0.02	0.05	0.03	0.02	0.03

Depth (cm)	MAY 30 Atrazine	MAY 30 De-ethyl Atrazine	JUNE 3 Atrazine	JUNE 3 De-ethyl Atrazine	JUNE 10 Atrazine	JUNE 10 De-ethyl Atrazine	JUNE 18 Atrazine	JUNE 18 De-ethyl Atrazine	JUNE 26 Atrazine	JUNE 26 De-ethyl Atrazine
0-5	1.20	0.18	1.10	0.13	1.40	0.14	1.30	0.38	0.69	0.24
0-5	1.10	0.22	0.97	0.18	1.50	0.17	0.80	0.21	1.40	0.30
0-5	0.96	0.20	0.97	0.14	1.30	0.16	1.10	0.48	0.81	0.26
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	1.09	0.20	1.01	0.15	1.40	0.16	1.07	0.36	0.97	0.27
(cm)										
30	0.03	0.02	0.05	0.02	0.02	0.03	0.04	0.05	0.02	0.01
30	0.02	0.01	0.05	0.02	0.07	0.03	0.04	0.05	0.02	0.01
30	0.03	0.03	0.07	0.02	0.03	0.03	0.03	0.02	0.04	0.04
	-----	-----	-----	-----	-----	-----	-----	----	-----	-----
Mean	0.03	0.02	0.06	0.02	0.04	0.03	0.04	0.04	0.03	0.02

Depth (cm)	JULY 9 Atrazine	JULY 9 De-ethyl Atrazine	JULY 23 Atrazine	JULY 23 De-ethyl Atrazine	AUGUST 6 Atrazine	AUGUST 6 De-ethyl Atrazine	AUGUST 20 Atrazine	AUGUST 20 De-ethyl Atrazine	SEPT 18 Atrazine	SEPT 18 De-ethyl Atrazine
0-5	0.72	0.23	0.37	0.17	0.42	0.28	0.52	0.29	0.29	0.09
0-5	0.45	0.15	0.87	0.35	0.52	0.31	0.41	0.23	0.35	0.11
0-5	0.63	0.19	0.46	0.17	0.39	0.20	0.34	0.18	0.31	0.07
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.60	0.19	0.57	0.23	0.44	0.26	0.42	0.23	0.32	0.09
(cm)										
30	0.03	0.03	0.04	ND	0.03	0.04	0.03	0.04	0.01	0.02
30	0.03	0.03	0.03	0.04	0.02	0.03	ND	ND	0.02	0.02
30	0.04	0.06	0.03	ND	0.03	0.04	0.03	0.05	0.02	0.01
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.03	0.04	0.03	0.01	0.03	0.04	0.02	0.03	0.02	0.02

TABLE A2 Continued

Depth (cm)	OCTOBER 8		NOVEMBER 5		DECEMBER 17		APRIL 3 1987	
	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine	Atrazine	De-ethyl Atrazine
0-5	0.33	0.08	0.21	0.10	0.19	0.11	0.19	0.08
0-5	0.50	0.12	0.16	0.09	0.28	0.13	0.14	0.06
0-5	0.54	0.15	0.18	0.09	0.28	0.10	0.07	0.03
	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.46	0.12	0.18	0.09	0.25	0.11	0.13	0.06
(cm)								
30	0.01	0.02	0.03	0.03	0.02	0.02	0.01	0.01
30	0.02	0.03	0.03	0.03	0.03	0.03	ND	0.01
30	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
	-----	-----	-----	-----	-----	-----	-----	-----
Mean	0.01	0.02	0.03	0.03	0.02	0.02	0.01	0.01

APPENDIX B

Photographs of Survey Methods

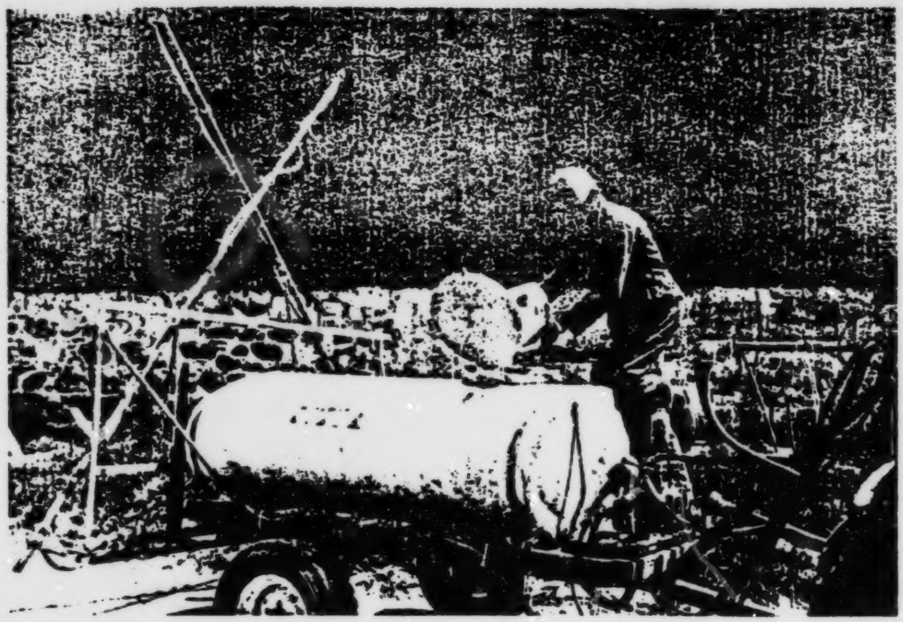

Photo B1. Farmer prepares sprayer & tank mixture.

Photo B2. Pre-plant spray application on study field.

Photo B4. Soil Sample Collection Apparatus.

APPENDIX B

MOE PESTICIDE USE SURVEYS

Atrazine Farm Survey, 1984–86

During the summer field seasons of 1984 to 1986, pesticide usage data were collected from the farm operators in the Holiday Creek Basin.

The data were obtained with the aid of pre-designed questionnaires (see attached example) which surveyed information on the types and amounts of pesticides used, types of crops and acreage, dates of application, plowing details, and map plots showing fields which were treated with atrazine products.

The questionnaires were hand-delivered to the farm operators and picked up one week later. If requested by the farm operator, the questionnaire was completed on site by the survey staff. If necessary, the questionnaire was completed by the operator and returned by mail.

Applied amounts of atrazine were subsequently calculated, based on the percentage of active ingredients in the product, the number of hectares treated, and the application rate. Table B1 lists atrazine products used along with the percentage of active ingredient in each. Tables B2 and B3 list the application rate, application area and timing of application for 1985 and 1986 respectively.

All atrazine information is reported as active ingredient.

TABLE B1: ACTIVE ATRAZINE CONTENT IN ATRAZINE PRODUCTS USED IN THE NISSOURI CREEK WATERSHED

Brand Name	Percentage of Active Ingredient
Atrazine 500 liquid	50
Aatrex	80
Aatrex-Plus flowable	40
Atrazine 90 WP	90
Aatrex Nine-0	90
Dual plus Atrazine	80
Primextra	20
Blazine	25

TABLE B2: SUMMARY OF NISSOURI CREEK WATERSHED ATRAZINE USEAGE SURVEY FOR 1985

Operator #	Area of Application (ha)	Application Rate (kg/ha)	Date of Application
1	8.0	1.88	PE
2	28.0	2.56	PE*
3	12.0	2.50	PE
4	7.2	0.07	PE
5	10.4	2.80	PE
6	10.0	4.40	PE
7	8.0	2.40	PR
8	22.4	1.80	PR & PE
9	34.0	3.79	PP & PR
10	6.0	5.00	PR
11	-	0	-
12	NA	NA	NA
13	24.0	0.85	PE
14	20.0	2.57	PE
15	34.0	1.52	PR
16	NA	NA	NA
17	NA	NA	NA
18	24.0	1.25	spring
19	32.0	3.38	PP, PR, PE
20	16.8	2.14	PE
21	9.6	2.05	PR
22	24.0	1.25	PE
23	6.4	6.39	PE
24	18.0	0.86	PR, PE
25	10.0	6.00	PE
26	34.0	2.27	PE
27	-	0	-
28	16.0	NA	NA
29	50.0	1.96	PE
30	NA	NA	NA
31	12.0	3.75	PE
32	2.0	2.05	PR
33	NA	NA	NA
34	2.8	2.05	NA
35	40.0	2.05	PP
36	60.0	3.07	PP
37	36.0	3.57	PP, PE
38	26.0	3.70	PE
39	47.2	1.86	PP, PR, PE
40	-	0	-

TABLE B2: (cont'd.)

SUMMARY OF NISSOURI CREEK WATERSHED ATRAZINE USEAGE SURVEY FOR 1985

Operator #	Area of Application (ha)	Application Rate (kg/ha)	Date of Application
41	84.0	1.23	PP
*42	60.0	5.68	PR, PE
43	34.0	2.05	PR
44	10.8	2.50	PR
45	38.0	2.89	PE
46	26.4	1.53	PR
47	18.0	1.02	PR
48	34.4	3.30	PE
49	NA	NA	NA
50	4.0	1.14	PE
51	56.0	1.25	NA
52	-	0	-
Totals	1,056.6	-	-
Weighted Average	-	1.85	-

PP pre-plant spray (probably late April - early May)
PR pre-emergent spray (probably early May)
PE post-emergent spray (probably late May - early June)
NA not available
- not applicable

TABLE B3: SUMMARY OF NISSOURI CREEK WATERSHED ATRAZINE USEAGE SURVEY FOR 1986

Operator #	Area of Application (ha)	Application Rate (kg/ha)	Date of Application
1	9.0	1.35	May 28
2	28.0	1.60	May 8-9
3	6.0	1.80	May 28
4	NA	NA	NA
5	10.0	2.25	June 15
6	11.0	1.61	June 7
7	18.0	1.60	Spring
8	16.0	1.26	May 10
9	13.0	1.80	May 15-20
10	2.0	4.05	NA
11	-	0	-
12	NA	NA	NA
13	4.5	1.73	May 8
14	32.0	2.53	June
15	26.0	2.27	Mid May
16	-	0	-
17	NA	NA	NA
18	20.0	3.13	May 10
19	12.0	4.27	April-June
20	18.0	2.03	NA
21	31.0	1.99	May 15
22	31.0	1.81	May 20
23	40.5	2.00	NA
24	12.0	2.83	Late May
25	20.5	4.50	May 15-28
26	28.0	1.40	May 12
27	93.0	0.99	May 10
28	6.5	2.22	June 15
29	34.0	2.25	May 20
30	NA	NA	NA
31	20.0	2.25	Mid May
32	12.0	2.25	June 15
33	NA	NA	NA
34	4.0	2.03	June
35	6.0	5.80	April 30, May 24
36	NA	NA	NA
37	32.0	3.95	June, October
38	NA	NA	NA
39	36.0	1.50	May
40	NA	NA	NA

TABLE B3: SUMMARY OF NISSOURI CREEK WATERSHED
(cont'd.) ATRAZINE USEAGE SURVEY FOR 1986

Operator #	Area of Application (ha)	Application Rate (kg/ha)	Date of Application
41	24.0	0.60	May 2
42	91.0	1.18	May
43	20.0	2.25	Mid May
44	11.0	0.99	May 17
45	48.0	1.38	May 26, June 6
46	28.0	3.15	May 28-30
47	21.0	2.00	May 13
48	28.0	2.14	May 20-24, June 13, July 14
49	NA	NA	NA
50	NA	NA	NA
51	49.0	1.22	NA
52	NA	NA	NA
Weighted Average	-	1.84	-
Totals	952.0	-	-

NA Not available
- Not applicable

NAME: ______________ ADDRESS: ______________________________ TELEPHONE: ____________________

FARM LOCATION: LOT: __________________ CONCESSION: __________________ TOWNSHIP: ____________________

LIVESTOCK OPERATION: YES: _____ NO: _____ WHAT TYPE: __________________ HERD, FLOCK SIZE: ______________

	1983	1984	1985	1986	1987
ACRES TREATED WITH ATRAZINE					
PRODUCTS USED					
NUMBERS OF YEARS ATRAZINE USED					
NUMBER OF YEARS CORN IS GROWN ON THE SAME FIELD					
NUMBER OF ACRES TILE DRAINED - SYSTEMATIC - RANDOM					
ACRES OF WOODLOT					
ACRES OF SWAMP					
TOTAL FARM ACREAGE					
COMMENTS					

APPENDIX C

HYDROLOGIC DATA

TABLE C1: Observed Daily Average Streamflow at Four Surface Water Monitoring Sites, 1985-86

Observed Average Daily Streamflow Stn. N1 (m**3/s)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.943	0.571	1.327	5.232	0.12[illegible]	0.079	0.070	0.045	0.105	0.106	0.155	2.265
2	6.672	1.159	1.703	2.020	0.114	0.061	0.072	0.030	0.104	0.094	0.152	2.720
3	1.216	1.045	1.270	2.125	0.105	[illegible]	0.081	0.026	0.070	0.090	0.282	0.949
4	0.518	2.316	3.625	2.734	0.100	[illegible]	0.070	0.020	0.090	0.091	1.286	0.640
5	0.245	2.382	3.972	6.020	0.106	0.050	0.070	0.022	0.175	0.106	2.273	0.567
6	0.142	0.665	1.241	3.517	0.124	0.045	0.100	0.027	0.135	0.123	0.915	0.520
7	0.129	0.429	0.847	1.773	0.105	0.043	0.074	0.036	0.105	0.104	0.681	0.488
8	0.404	0.377	2.379	1.372	0.090	0.042	0.161	0.043	0.571	0.100	0.602	0.460
9	0.137	0.462	2.772	1.018	0.083	0.102	0.297	0.030	0.373	0.153	0.780	0.438
10	0.166	0.362	3.020	0.811	0.076	0.065	0.117	0.030	0.230	0.143	3.564	0.496
11	0.168	0.541	4.001	0.687	0.070	0.066	0.085	0.030	0.171	0.124	1.334	0.723
12	0.098	0.770	6.020	0.438	0.067	0.098	0.313	0.036	0.127	0.319	0.845	0.693
13	0.100	1.483	2.602	0.403	0.060	0.082	0.127	0.037	0.103	0.883	1.993	0.583
14	0.093	0.623	2.654	0.368	0.053	0.079	0.098	0.047	0.097	0.511	1.271	0.469
15	0.098	0.581	2.380	0.329	0.060	0.071	0.096	0.095	0.086	0.405	0.947	0.400
16	0.130	0.500	2.480	0.277	0.085	0.698	0.096	0.077	0.085	0.344	0.985	0.368
17	0.305	0.418	2.410	0.229	0.082	0.739	0.079	0.055	0.085	0.268	1.109	0.465
18	0.197	0.346	1.067	0.202	0.070	1.244	0.068	0.049	0.075	0.431	1.212	0.297
19	0.083	0.306	0.987	0.200	0.070	0.475	0.098	0.050	0.070	3.129	1.717	0.308
20	0.135	0.344	1.352	0.200	0.145	0.281	0.130	0.050	0.070	1.140	1.316	0.276
21	0.436	0.213	1.108	0.182	0.192	0.163	0.084	0.042	0.075	0.612	0.740	0.234
22	0.640	6.513	1.154	0.161	0.123	0.215	0.076	0.0[illegible]0	0.076	0.460	0.606	0.280
23	0.644	14.345	1.084	0.144	0.076	0.229	0.060	0.040	0.070	0.382	0.527	0.244
24	0.635	17.053	0.968	0.165	0.068	0.143	0.054	0.135	0.093	0.345	0.487	0.276
25	0.665	9.102	0.675	0.227	0.060	0.109	0.053	0.143	0.086	0.307	0.430	0.240
26	0.589	4.718	0.800	0.173	0.069	0.096	0.050	0.978	0.093	0.259	0.750	0.234
27	0.672	2.987	3.527	0.151	0.153	0.087	0.047	0.435	0.097	0.216	1.137	0.203
28	0.583	2.085	8.310	0.148	0.105	0.080	0.040	0.180	0.090	0.187	0.905	0.224
29	0.480		3.670	0.147	0.076	0.080	0.043	0.123	0.084	0.171	0.654	0.233
30	0.438		2.405	0.155	0.070	0.075	0.040	0.176	0.081	0.172	0.635	0.220
31	0.622		4.813		0.093		0.045	0.149		0.157		0.250
AVER	0.819	2.596	2.472	1.054	0.093	0.190	0.093	0.106	0.126	0.385	0.997	0.539

AVER OF MONTHLY VALUES 7.89164E-01

Observed Average Daily Streamflow Stn. N2 (m**3/s)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	********	********	********	********	0.045	0.025	0.016	0.010	0.017	0.026	0.056	********
2	********	********	********	********	0.038	0.019	0.019	0.006	0.022	0.017	0.067	********
3	********	********	********	********	0.036	0.018	0.016	0.005	0.014	0.015	0.152	********
4	********	********	********	********	0.034	0.017	0.014	0.004	0.028	0.015	0.312	********
5	********	********	********	********	0.041	0.016	0.015	0.007	0.049	0.017	0.398	********
6	********	********	********	********	0.048	0.016	0.018	0.013	0.029	0.023	0.280	********
7	********	********	********	********	0.045	0.015	0.015	0.016	0.019	0.021	0.254	********
8	********	********	********	********	0.037	0.016	0.042	0.017	0.136	0.018	0.224	********
9	********	********	********	********	0.035	0.050	0.039	0.013	0.074	0.038	0.262	********
10	********	********	********	********	0.030	0.021	0.024	0.012	0.046	0.036	0.480	********
11	********	********	********	0.137	0.029	0.029	0.019	0.013	0.028	0.026	0.303	********
12	********	********	********	0.076	0.030	0.036	0.041	0.012	0.017	0.092	0.222	********
13	********	********	********	0.074	0.027	0.021	0.025	0.011	0.014	0.260	0.363	********
14	********	********	********	0.069	0.024	0.018	0.021	0.010	0.013	0.142	0.324	********
15	********	********	********	0.065	0.027	0.017	0.028	0.015	0.012	0.124	0.251	********
16	********	********	********	0.060	0.030	0.122	0.026	0.023	0.012	0.101	0.260	********
17	********	********	********	0.054	0.026	0.178	0.020	0.009	0.012	0.080	0.274	********
18	********	********	********	0.054	0.022	0.265	0.019	0.008	0.012	0.135	0.272	********
19	********	********	********	0.052	0.039	0.150	0.030	0.007	0.013	0.479	0.349	********
20	********	********	********	0.048	0.032	0.077	0.036	0.006	0.012	0.302	0.292	********
21	********	********	********	0.043	0.027	0.038	0.017	0.005	0.012	0.206	0.199	********
22	********	********	********	0.052	0.029	0.064	0.013	0.005	0.012	0.158	0.163	********
23	********	********	********	0.049	0.032	0.057	0.009	0.005	0.012	0.131	0.152	********
24	********	********	********	0.059	0.028	0.028	0.006	0.055	0.014	0.126	0.138	********
25	********	********	********	0.067	0.023	0.021	0.006	0.046	0.018	0.113	0.118	********
26	********	********	********	0.064	0.020	0.020	0.012	0.188	0.021	0.096	0.202	********
27	********	********	********	0.051	0.067	0.017	0.011	0.060	0.018	0.083	0.178	********
28	********	********	********	0.051	0.039	0.016	0.009	0.027	0.015	0.071	0.225	********
29	********		********	0.072	0.025	0.016	0.010	0.019	0.013	0.061	0.174	********
30	********		********	0.062	0.020	0.016	0.008	0.034	0.014	0.059	0.176	********
31	********		********		0.036		0.010	0.025		0.059		********
AVER	********	********	********	********	0.034	0.047	0.019	0.022	0.024	0.101	0.241	********

```
               Observed Average Daily Streamflow Stn. N3 (m**3/s)

          ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY      JAN     FEB     MAR     APR     MAY     JUN     JUL     AUG     SEP     OCT     NOV     DEC

  1 ################################   0.035   0.014   0.030   0.008   0.025   0.025   0.036########
  2 ################################   0.033   0.013   0.034   0.006   0.021   0.016   0.036########
  3 ################################   0.029   0.011   0.038   0.006   0.017   0.012   0.062########
  4 ################################   0.026   0.012   0.026   0.006   0.025   0.014   0.255########
  5 ################################   0.027   0.013   0.016   0.005   0.045   0.016   0.370########

  6 ################################   0.028   0.012   0.019   0.007   0.032   0.017   0.173########
  7 ################################   0.024   0.014   0.016   0.008   0.020   0.013   0.139########
  8 ################################   0.023   0.019   0.045   0.009   0.052   0.012   0.123########
  9 ################################   0.022   0.036   0.043   0.006   0.035   0.022   0.157########
 10 ################################   0.019   0.021   0.021   0.006   0.029   0.021   0.581########

 11 ########################   0.125   0.018   0.024   0.015   0.010   0.023   0.018   0.222########
 12 ########################   0.069   0.021   0.026   0.023   0.008   0.016   0.055   0.149########
 13 ########################   0.067   0.020   0.024   0.014   0.008   0.013   0.171   0.272########
 14 ########################   0.063   0.019   0.024   0.013   0.014   0.014   0.089   0.266########
 15 ########################   0.059   0.019   0.028   0.016   0.023   0.012   0.071   0.190########

 16 ########################   0.054   0.019   0.095   0.014   0.016   0.011   0.059   0.193########
 17 ########################   0.049   0.017   0.232   0.014   0.013   0.010   0.046   0.211########
 18 ########################   0.049   0.017   0.234   0.014   0.011   0.011   0.091   0.235########
 19 ########################   0.047   0.016   0.132   0.018   0.011   0.012   0.433   0.280########
 20 ########################   0.043   0.017   0.094   0.021   0.011   0.010   0.201   0.231########

 21 ########################   0.039   0.016   0.066   0.016   0.010   0.010   0.122   0.144########
 22 ########################   0.039   0.015   0.076   0.015   0.010   0.011   0.092   0.120########
 23 ########################   0.040   0.016   0.067   0.013   0.007   0.011   0.078   0.104########
 24 ########################   0.042   0.012   0.052   0.012   0.032   0.016   0.073   0.096########
 25 ########################   0.045   0.012   0.043   0.009   0.030   0.013   0.065   0.085########

 26 ########################   0.039   0.013   0.038   0.010   0.103   0.019   0.057   0.130########
 27 ########################   0.037   0.019   0.035   0.009   0.052   0.016   0.050   0.191########
 28 ########################   0.037   0.015   0.032   0.008   0.032   0.014   0.042   0.165########
 29 ########        ########   0.033   0.014   0.032   0.009   0.026   0.011   0.037   0.131########
 30 ########        ########   0.034   0.013   0.030   0.009   0.033   0.014   0.037   0.130########
 31 ########        ########           0.016           0.011   0.029           0.037           ########

AVER ################################   0.020   0.052   0.018   0.018   0.019   0.067   0.183########
```

Observed Total Daily Surface Flow Stn N4 (m**3)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	#####	#####	#####	#####	0.000	0.000	40.030	0.000	0.000	0.000	0.000	181.760
2	#####	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	68.160
3	#####	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	18.700	0.000
4	#####	#####	#####	#####	0.000	0.000	0.000	0.000	5.040	0.000	53.100	0.000
5	#####	#####	#####	#####	0.000	0.000	1.440	0.000	3.600	0.000	35.400	#####
6	#####	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#####
7	#####	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	8.800	#####
8	#####	#####	#####	#####	0.000	0.000	37.370	0.000	7.130	0.000	0.000	#####
9	#####	#####	#####	#####	0.000	10.050	0.000	0.000	0.830	0.000	67.860	#####
10	#####	#####	#####	#####	0.000	0.000	0.000	0.000	2.020	0.000	88.740	#####
11	#####	#####	#####	#####	0.000	20.240	0.000	0.000	0.000	0.000	0.000	#####
12	#####	#####	#####	0.000	0.000	0.000	5.040	0.000	0.000	34.280	0.000	#####
13	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	25.590	40.700	#####
14	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.820	#####
15	#####	#####	#####	0.000	0.000	34.900	2.050	4.460	0.000	0.000	0.000	#####
16	#####	#####	#####	0.000	0.000	14.980	0.000	0.000	0.000	0.000	18.410	#####
17	#####	#####	#####	0.000	0.000	820.000	0.000	0.000	0.000	0.000	0.000	#####
18	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	34.520	56.160	#####
19	#####	#####	#####	0.000	0.000	0.000	7.780	0.000	0.000	41.140	9.940	#####
20	#####	#####	#####	0.000	1.720	0.000	0.000	0.000	0.000	0.000	0.000	#####
21	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#####
22	#####	#####	#####	0.000	0.000	10.020	0.000	0.000	0.000	0.000	0.000	#####
23	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#####
24	#####	#####	#####	1.550	0.000	0.000	0.000	24.780	0.000	0.000	0.000	#####
25	#####	#####	#####	0.000	0.000	0.000	0.000	1.160	0.000	0.000	0.000	#####
26	#####	#####	#####	0.000	0.000	0.000	0.000	38.940	0.000	0.000	0.000	#####
27	#####	#####	#####	0.000	3.820	0.000	0.000	0.000	0.000	0.000	0.000	#####
28	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#####
29	#####		#####	0.000	0.000	0.000	0.000	1.370	0.000	0.000	0.000	#####
30	#####		#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#####
31	#####		#####		3.120		0.000	0.000		0.000		#####
SUM	#####	#####	#####	#####	8.660	910.190	93.710	70.710	18.620	135.530	406.630	#####

Observed Average Daily Streamflow Stn. N1 (m**3/s)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.255	0.234	0.242	0.378	0.194	0.109	0.093	0.098	0.082	1.890	0.282	0.324
2	0.255	0.244	0.213	0.331	0.163	0.099	0.090	0.092	0.082	1.241	0.335	0.370
3	0.248	0.224	0.167	0.285	0.150	0.093	0.083	0.104	0.083	1.023	0.325	0.873
4	0.240	0.271	0.169	0.277	0.146	0.093	0.077	0.091	0.082	1.478	0.292	0.707
5	0.229	0.455	0.187	0.299	0.142	0.103	0.080	0.084	0.084	1.339	0.269	0.507
6	0.319	0.433	0.250	0.369	0.158	0.108	0.076	0.089	0.079	1.146	0.250	0.456
7	0.321	0.794	0.488	0.315	0.174	0.103	0.073	0.279	0.075	0.789	0.233	0.423
8	0.284	0.673	0.517	0.283	0.142	0.108	0.071	0.481	0.072	0.635	0.250	0.386
9	0.284	0.371	0.464	0.256	0.132	0.088	0.073	0.570	0.068	0.592	0.257	0.576
10	0.310	0.273	1.429	0.243	0.126	0.081	0.061	0.274	0.278	0.467	0.228	0.860
11	0.299	0.291	3.105	0.245	0.122	0.101	0.060	0.216	0.948	0.384	0.226	0.625
12	0.296	0.263	1.511	0.234	0.116	0.610	0.142	0.159	1.102	0.356	0.223	0.499
13	0.280	0.259	1.408	0.216	0.111	0.308	0.119	0.132	0.688	0.937	0.211	0.425
14	0.324	0.267	1.832	0.209	0.111	0.209	0.108	0.119	0.435	1.442	0.228	0.385
15	0.337	0.217	1.812	0.267	0.118	0.173	0.091	0.118	0.501	0.865	0.210	0.343
16	0.297	0.202	1.325	0.445	0.162	0.221	0.187	0.110	0.697	0.611	0.217	0.327
17	0.431	0.204	1.206	0.428	0.142	0.225	0.139	0.099	0.441	0.492	0.222	0.336
18	0.971	0.212	1.447	0.326	0.140	0.159	0.127	0.088	0.328	0.421	0.212	0.811
19	1.809	0.252	4.764	0.279	0.327	0.141	0.405	0.075	0.266	0.378	0.195	0.838
20	1.911	0.337	2.109	0.298	0.703	0.130	0.256	0.069	0.260	0.369	0.191	0.660
21	1.206	0.404	1.033	0.915	0.683	0.111	0.156	0.070	0.250	0.361	0.192	0.543
22	0.827	0.616	0.824	0.626	0.434	0.109	0.116	0.067	0.356	0.331	0.192	0.000
23	0.598	0.279	1.051	0.442	0.449	0.132	0.098	0.083	0.605	0.313	0.224	0.000
24	0.470	0.273	1.051	0.359	0.381	0.125	0.087	0.099	0.518	0.284	0.425	0.000
25	0.409	0.344	1.080	0.303	0.281	0.113	0.079	0.079	0.372	0.282	0.369	0.000
26	0.369	0.266	1.316	0.261	0.222	0.102	0.568	0.091	0.316	0.280	1.017	0.000
27	0.555	0.283	1.029	0.232	0.180	0.157	0.196	0.110	0.604	0.322	1.174	0.000
28	0.375	0.251	0.704	0.217	0.160	0.154	0.138	0.091	0.536	0.430	0.686	0.000
29	0.318		0.642	0.201	0.139	0.117	0.162	0.091	1.723	0.372	0.497	0.000
30	0.261		0.545	0.189	0.126	0.100	0.120	0.090	3.556	0.325	0.397	0.000
31	0.242		0.430		0.118		0.101	0.087		0.284		0.000
AVER	0.495	0.328	1.108	0.324	0.218	0.149	0.137	0.139	0.516	0.659	0.334	0.364

AVER OF MONTHLY VALUES 3.97624E-01

```
                 Observed Average Daily Streamflow Stn. N2 (m**3/s)

               ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

 DAY      JAN      FEB      MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

   1  ########################  0.108  0.077  0.028  0.016  0.033  0.014  0.387  0.070  0.076
   2  ########################  0.090  0.049  0.026  0.014  0.033  0.013  0.276  0.100  0.085
   3  ########################  0.063  0.040  0.025  0.012  0.033  0.013  0.222  0.085  0.246
   4  ########################  0.069  0.034  0.023  0.011  0.016  0.014  0.324  0.077  0.191
   5  ########################  0.082  0.028  0.028  0.011  0.013  0.015  0.290  0.069  0.135

   6  ########################  0.104  0.057  0.027  0.011  0.013  0.014  0.258  0.060  0.111
   7  ########################  0.076  0.056  0.026  0.010  0.050  0.015  0.178  0.054  0.104
   8  ########################  0.065  0.030  0.029  0.010  0.146  0.016  0.140  0.066  0.098
   9  ########################  0.058  0.022  0.021  0.010  0.175  0.016  0.157  0.068  0.136
  10  ########################  0.052  0.019  0.018  0.009  0.084  0.166  0.123  0.056  0.209

  11  ########################  0.058  0.033  0.034  0.009  0.062  0.391  0.106  0.056  0.151
  12  ########################  0.053  0.028  0.267  0.058  0.043  0.431  0.097  0.053  0.120
  13  ########################  0.044  0.025  0.125  0.039  0.033  0.275  0.240  0.047  0.096
  14  ########################  0.042  0.026  0.072  0.029  0.028  0.173  0.320  0.042  0.083
  15  ########################  0.085  0.032  0.055  0.013  0.026  0.242  0.198  0.043  0.076

  16  ########################  0.162  0.050  0.065  0.062  0.023  0.287  0.142  0.045  0.076
  17  ########################  0.124  0.029  0.067  0.039  0.020  0.199  0.120  0.049  0.080
  18  ########################  0.080  0.040  0.044  0.051  0.018  0.136  0.103  0.047  0.193
  19  ########################  0.060  0.181  0.035  0.131  0.017  0.082  0.092  0.040  0.198
  20  ########################  0.067  0.335  0.033  0.108  0.016  0.093  0.084  0.036  0.152

  21  ########################  0.365  0.287  0.024  0.056  0.013  0.087  0.078  0.036  0.121
  22  ########################  0.201  0.154  0.021  0.035  0.011  0.151  0.072  0.038  #####
  23  ########################  0.117  0.190  0.032  0.028  0.025  0.206  0.070  0.052  #####
  24  ########################  0.079  0.130  0.031  0.021  0.024  0.154  0.068  0.114  #####
  25  ################   0.382  0.058  0.083  0.020  0.019  0.014  0.095  0.065  0.094  #####

  26  ################   0.504  0.052  0.069  0.015  0.202  0.016  0.066  0.065  0.257  #####
  27  ################   0.411  0.040  0.041  0.057  0.076  0.029  0.148  0.096  0.306  #####
  28  ################   0.244  0.037  0.050  0.051  0.058  0.019  0.124  0.125  0.179  #####
  29  ########           0.242  0.035  0.041  0.028  0.069  0.025  0.392  0.104  0.128  #####
  30  ########           0.202  0.033  0.034  0.019  0.044  0.017  0.673  0.086  0.102  #####
  31  ########           0.135         0.030         0.035  0.015         0.074         #####
AVER  ########################  0.085  0.074  0.045  0.042  0.035  0.157  0.154  0.082 ######
```

```
                  Observed Average Daily Streamflow Stn. N3 (m**3/s)

             ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY      JAN     FEB     MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

  1  ########################  0.078  0.057  0.031  0.020  0.028  0.028  0.469  0.048  0.079
  2  ########################  0.071  0.052  0.030  0.021  0.028  0.028  0.225  0.055  0.088
  3  ########################  0.067  0.049  0.029  0.023  0.027  0.027  0.164  0.054  0.235
  4  ########################  0.064  0.048  0.031  0.025  0.013  0.027  0.424  0.051  0.176
  5  ########################  0.065  0.047  0.034  0.028  0.011  0.027  0.264  0.049  0.123

  6  ########################  0.071  0.049  0.029  0.029  0.011  0.026  0.169  0.047  0.109
  7  ########################  0.069  0.048  0.027  0.031  0.076  0.026  0.097  0.045  0.102
  8  ########################  0.066  0.044  0.027  0.033  0.164  0.026  0.073  0.049  0.090
  9  ########################  0.063  0.041  0.025  0.034  0.152  0.025  0.065  0.050  0.139
 10  ########################  0.060  0.038  0.027  0.034  0.075  0.050  0.052  0.046  0.203

 11  ########################  0.059  0.038  0.031  0.034  0.061  0.213  0.048  0.047  0.144
 12  ########################  0.058  0.037  0.103  0.044  0.042  0.321  0.049  0.046  0.111
 13  ########################  0.056  0.039  0.054  0.040  0.037  0.117  0.146  0.044  0.084
 14  ########################  0.055  0.040  0.041  0.039  0.034  0.067  0.321  0.044  0.083
 15  ########################  0.063  0.038  0.037  0.035  0.034  0.109  0.111  0.046  0.079

 16  ########################  0.095  0.040  0.042  0.050  0.032  0.146  0.081  0.047  0.072
 17  ########################  0.086  0.037  0.042  0.042  0.031  0.077  0.071  0.049  0.072
 18  ########################  0.072  0.038  0.035  0.167  0.029  0.061  0.064  0.047  0.178
 19  ########################  0.067  0.054  0.035  0.145  0.029  0.051  0.059  0.045  0.179
 20  ########################  0.070  0.141  0.033  0.082  0.028  0.050  0.056  0.047  0.144

 21  ########################  0.185  0.111  0.032  0.053  0.029  0.047  0.052  0.046  0.119
 22  ########################  0.117  0.069  0.033  0.034  0.029  0.062  0.049  0.047  #####
 23  ########################  0.089  0.071  0.034  0.023  0.031  0.089  0.048  0.055  #####
 24  ########################  0.078  0.060  0.034  0.017  0.030  0.077  0.045  0.101  #####
 25  ################   0.359  0.073  0.049  0.030  0.015  0.029  0.061  0.045  0.086  #####

 26  ################   0.380  0.066  0.042  0.028  0.169  0.030  0.054  0.045  0.399  #####
 27  ################   0.243  0.060  0.038  0.037  0.064  0.030  0.075  0.054  0.273  #####
 28  ################   0.162  0.059  0.035  0.031  0.049  0.029  0.071  0.064  0.182  #####
 29  ########           0.143  0.057  0.033  0.025  0.057  0.029  0.689  0.057  0.125  #####
 30  ########           0.118  0.056  0.031  0.021  0.037  0.029  1.550  0.051  0.096  #####
 31  ########           0.088         0.031         0.029  0.028         0.047         #####
AVER ########################  0.073  0.050  0.035  0.048  0.041  0.143  0.115  0.079 #######
```

Observed Total Daily Surface Flow Stn N4 (m**3)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	#####	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	12.600	0.000
2	#####	#####	#####	0.000	0.000	0.000	0.000	30.240	0.000	0.000	0.000	32.400
3	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	12.600	0.000	0.000
4	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	30.240	0.000	0.000
5	#####	#####	#####	8.640	0.000	0.000	0.000	56.160	0.000	15.120	0.000	0.000
6	#####	#####	#####	0.000	21.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	#####	#####	#####	0.000	0.000	0.000	0.000	145.800	0.000	0.000	0.000	0.000
8	#####	#####	#####	0.000	0.000	0.000	0.000	51.840	0.000	20.160	0.000	0.000
9	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	47.520
10	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	78.840	0.000	0.000	0.000
11	#####	#####	#####	0.000	0.000	21.240	3.384	0.000	71.280	0.000	0.000	0.000
12	#####	#####	#####	0.000	0.000	45.360	27.072	0.000	27.360	30.240	0.000	0.000
13	#####	#####	#####	0.000	0.000	0.000	8.964	0.000	0.000	0.000	0.000	0.000
14	#####	#####	#####	0.000	0.000	0.000	5.976	0.000	0.000	0.000	0.000	0.000
15	#####	#####	#####	4.320	0.000	0.000	0.000	0.000	75.600	0.000	0.000	0.000
16	#####	#####	#####	12.600	21.600	28.080	7.920	0.000	0.000	0.000	0.000	0.000
17	#####	#####	#####	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	#####	#####	#####	0.000	24.840	0.000	92.880	0.000	0.000	0.000	0.000	2.052
19	#####	#####	#####	0.000	37.152	0.000	0.000	0.000	0.000	0.000	0.000	0.540
20	#####	#####	#####	14.760	75.240	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	#####	#####	#####	22.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	#####	#####	#####	0.000	0.000	16.200	0.000	0.000	20.160	0.000	0.000	0.000
23	#####	#####	#####	0.000	1.512	0.000	0.000	16.200	10.080	0.000	0.000	#####
24	#####	#####	#####	0.000	2.016	15.120	0.000	0.000	0.000	0.000	0.000	#####
25	#####	#####	#####	0.000	0.000	0.000	30.240	0.000	0.000	0.000	0.000	#####
26	#####	#####	#####	0.000	0.000	0.000	30.240	0.000	0.000	0.000	23.040	#####
27	#####	#####	#####	0.000	0.000	93.240	0.000	0.000	20.160	37.800	0.000	#####
28	#####	#####	#####	0.000	0.000	0.000	15.120	0.000	0.000	0.000	0.000	#####
29	#####		#####	0.000	0.000	0.000	0.000	0.000	93.960	0.000	0.000	#####
30	#####		#####	0.000	0.000	0.000	0.000	0.000	63.720	0.000	0.000	#####
31	#####		#####		0.000		0.000	0.000		0.000		#####
SUM	#####	#####	#####	62.820	183.960	219.240	221.796	300.240	461.160	146.160	35.640	#####

TABLE C2 GROUNDWATER LEVELS (cm)[1]

Date	Piezometer # P1	P2	P3
1986:			
April 8	36"	36"	38"
August 11	36"	50"	41 1/2"
September 18	36"	48"	50"
October 20	39"	36"	41"

---

[1] measured from the ground surface

TABLE C3 TILE DRAIN OUTFLOW RATES, 1985-86

		Flow Rates (litres/sec.)			
Outfall #		T1	T2	T3	T4
1984:					
Sept.	1	0.86		0.15	1.70
	10	2.65		0.24	2.30
	21	1.90		0.70	2.80
Oct.	11	1.50		-	2.20
	19	20.67		5.33	9.00
Nov.	2	3.05		0.49	3.23
	17	20.67		5.33	9.00
	30	12.80	0.30	2.70	7.00
Dec.	12	40.0	2.25	12.0	30.0
	21	16.0	0.54	5.5	9.6
1985:					
April	22	1.10	0.30	0.30	3.70
May	2	0.90		0.30	3.50
	16	0.40		0.20	3.30
	22	0.30		0.30	3.40
	28	2.70		0.40	4.00
June	7	0.30		0.20	3.50
July	4	0.70		0.30	3.80
	19	0.70		0.20	3.30
Aug.	5			0.04	1.20
	17			0.03	1.20
Sept.	2				
Oct.	30	5.20	0.058	1.80	3.45
1986:					
April	8	5.75	0.148	5.00	6.17
May	1	5.69	0.125	2.84	11.40
	13	1.14	0.065	0.60	2.85
	20	76.0	6.00	tile submerged	45.0
	20	103	4.00	tile submerged	36.0
	21	61.8	2.2	24.0	41.0
	21	50.9	2.0	24.0	39.0
	22	33.6	1.0	12.0	24.0
	26	13.1	0.37	4.0	10.0
June	5	1.80	0.025	0.60	4.0
	24	3.30	1.14	0.70	4.0
Sept.	3	0.100		0.05	0.300
	11	52.0	3.00		35.0
	25	22.4	0.50		6.5

APPENDIX D

WATER QUALITY DATA

TABLE D1

MAXIMUM AND MINIMUM ATRAZINE, SUSPENDED SOLIDS AND TOTAL PHOSPHORUS CONCENTRATIONS IN SURFACE WATER SAMPLES, 1984-86

		Atrazine (ug/l)				Total Suspended Solids (mg/l)				Total Phosphorous (mg/l)			
Station	Year	Minimum	Sample Date	Maximum	Sample Date	Minimum	Sample Date	Maximum	Sample Date	Minimum	Sample Date	Maximum	Sample Date
N1	84	0.03	Aug. 23	180	June 26	0.278	Oct. 11	1597.500	July 7	0.014	May 18	3.150	July 17
	85	0.36	Aug. 5	36	June 18	0.216	May 2	576	Oct. 12	0.013	May 16	3.850	June 17
	86	0.27	Sept. 3	8.9	July 18	1.452	March 4	879	July 18	0.014	May 13	1.390	July 19
N2	84	0.08	Aug. 23	12	July 12	0.112	Oct. 19	280.500	July 17	0.029	Oct. 11	0.590	July 17
	85	0.17	Jan. 3	30.0	June 17	-0.017(T)	Sept. 25	581.2	Oct. 18	0.014	Aug. 5	0.855	Oct. 18
	86	0.0	Sept. 3	5.6	July 18	0.10	Nov. 18	84.8	June 11	0.017	Feb. 24	0.260	March 19
N3	84	0.13	Nov. 9	350	June 26	1.560	Aug. 22	2723.300	July 7	0.018	Aug. 22	3.430	July 7
	85	0.09	Aug. 5	47	June 18	1.08	Sept. 25	168.4	July 6	0.009	May 2	0.605	March 8
	86	0.00	Sept. 3	3.1	June 6	1.80	Nov. 5	1250	Aug. 7	0.022	Nov. 5	2.48	Aug. 7
N4	84	0.35	May 22	200	June 21	0.652	July 5	1794.800	June 28	0.029	May 18	2.100	June 28
	85	0.90	March 29	425	May 27	-0.067(T)	Aug. 5	1209.0	Oct. 13	0.018	April 24	3.88	June 18
	86	3.5	May 16	290	June 11	5.1	Dec. 19	923.0	May 16	0.079	May 1	0.720	May 16

(T) Low measurement, tentative, for info only

All measurements in mg/l

Table D2 Total (T.P.) and Reactive (T.R.P.) Phosphorous Concentrations (mg/l)
Station N1 and Tile Drains, 1984-1986

SAMPLE	N1		T1		T2		T3		T4	
DATE	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.
May 18	0.014	0.0030								
June 08	0.112	0.0480								
09	1.250	0.1880								
13	0.033	0.0100								
17	0.540	0.1900								
18	0.205	0.0995								
19	0.111	0.0550								
24	0.069	0.0205								
24	0.073	0.0225								
24	0.057	0.0275								
28	1.300	0.3000								
July 05	0.062	0.0265								
07	1.980	0.2430							0.028	0.0290
07	0.175	0.0730								
16	0.680	0.0890								
17	3.150	0.2500								
17	0.320	0.0895								
Aug 02			0.036	0.0110			0.024	0.0240	0.015	0.0140
22	0.028	0.0150	0.045	0.0010			0.024	0.0220	0.007	0.0055
31	0.133	0.0230	0.019	0.0105			0.047	0.0385	0.023	0.0180
Sept 04	0.343	0.1380								
10	0.130	0.1000	0.014	0.0050			0.840	0.6380	0.133	0.1080
11	0.530	0.1760								
12	0.370	0.1020								
21	0.032	0.0240	0.009	0.0045			0.670	0.5110	0.119	0.0735
Oct 11	0.039	0.0325	0.008	0.0020			0.027	0.0215	0.014	0.0085
19	0.024	0.0150	0.018	0.0060			0.030	0.0325	0.077	0.0510
Nov 01	0.016	0.0035								
01	0.020	0.0045								
01	0.020	0.0075								
01	0.081	0.0100								
02	0.028	0.0120	0.008	0.0035			0.003	0.0030	1.400	0.0175
02	0.042	0.0165								
02	0.035	0.0120								
02	0.037	0.0110								
15	0.318	0.0500	0.024	0.0175			0.054	0.0420	0.019	0.0120
16	0.318	0.0500	0.024	0.0175			0.054	0.0420	0.019	0.0120
17	0.318	0.0500	0.024	0.0175			0.054	0.0420	0.019	0.0120
30	0.101	0.0270	0.015	0.0120	0.017	0.0170	0.022	0.0200	0.015	0.0105
Dec 12	0.084	0.044[illegible]	0.038	0.0165	0.038	0.0285	0.085	0.0740	0.067	0.0375
21	0.052	0.0345	0.017	0.0040	0.013	0.0130	0.016	0.0150	0.011	0.0100
1985										
Feb 13	0.165	0.0360							0.034	0.0015
24	0.240	0.0950								
25	0.285	0.1450							0.122	0.0655
26	0.320	0.1250								
March 08	0.525	0.2260							0.068	0.0345
29	0.148	0.0610	0.034	0.0145					0.082	0.0460
April 22	0.068	0.0275	0.018	0.0030	0.068	0.0425	0.405	0.2550	0.030	0.0140
May 02	0.017	0.0170	0.011	0.0030			0.019	0.0220	0.016	0.0130
16	0.013	0.0050	0.005	0.0015			0.022	0.0220	0.022	0.0140

Table D2 Total (T.P.) and Reactive (T.R.P.) Phosphorous Concentrations (mg/l)
Station N1 and Tile Drains, 1984-1986

SAMPLE	N1		T1		T2		T3		T4	
DATE	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.
21	0.062	0.0080	0.004	0.0020			0.021	0.0210	0.010	0.0085
27	0.091	0.0510	0.024	0.0035			0.023	0.0230	0.018	0.0130
29	0.091	0.0415								
June 07	0.025	0.0120	0.007	0.0030			0.022	0.0210	0.007	0.0060
09	0.063	0.0330								
12	0.094	0.0455								
16	1.480	0.2280								
17	0.099	0.0535								
17	0.179	0.0685								
17	3.850	0.2730								
18	0.815	0.0910								
18	0.343	0.0830								
18	0.358	0.0855								
18	0.700	0.1530								
19	0.375	0.0725								
19	0.260	0.0725								
23	0.560	0.0760								
July 04	0.046	0.0215	0.013	0.0030			0.027	0.0240	0.032	0.0120
07	0.238	0.0575								
12	1.580	0.0475								
19	0.059	0.0365	N/A	N/A			0.530	0.5060	0.015	0.0100
Aug 05	0.079	0.0320					0.041	0.0400	0.002	0.0025
17	0.054	0.0460					0.047	0.0470	0.002	0.0040
25	0.620	0.1870								
Sept 02	0.005	0.0040	0.055	0.0440			0.017	N/A	0.006	0.0060
06	0.024	N/A								
25	0.036	0.0140	0.026	0.0035			0.019	0.0170	0.006	0.0020
Oct 15	1.060	0.0345								
22	1.060	0.0815								
22	0.485	0.1280								
22	0.174	0.0600								
22	0.156	0.0370								
30	0.014	0.0115	0.013	0.0080	0.032	N/A	0.034	N/A	0.015	0.0135
Nov 14	0.086	0.0625	0.041	0.0375	0.047	0.0420	0.300	0.2200	0.046	0.0260
19	0.153	0.0635								
Dec 10	0.035	0.0250	0.011	0.0075	0.026	0.0250	0.130	0.1110	0.016	0.0130
1986										
Feb 12	0.035	0.0250								
24	0.029	0.0165	0.010	0.0020					0.014	0.0045
March 04	0.037	0.0185	0.007	0.0020			0.059	0.0520	0.020	0.0085
10	0.175	0.1070								
11	0.430	0.1820								
11	0.358	0.1220								
12	0.175	0.1070								
12	0.160	0.0820								
13	0.150	0.0750								
18	0.127	0.0800								
19	0.410	0.1650	0.263	0.0725					0.134	0.0700
19	0.490	0.1600								
20	0.119	0.0620								
April 08	0.023	0.0105	0.008	0.0020	0.033	0.0245	0.053	0.0425	0.018	0.0110

Table D2 Total (T.P.) and Reactive (T.R.P.) Phosphorous Concentrations (mg/l)
Station N1 and Tile Drains. 1984-1986

SAMPLE DATE	N1		T1		T2		T3		T4	
	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.	T.P.	T.R.P.
20	0.173	0.0665								
May 01	0.019	0.0075	0.012	0.0020	0.019	0.1190	0.050	0.0460	0.027	0.0115
13	0.014	0.0030	0.014	0.0020	0.220	0.2200	0.024	0.0240	0.013	0.0095
20	0.353	0.1480								
21	0.215	0.0965								
21	0.125	0.0520								
22	0.103	0.0395								
26	0.041	0.0295	0.011	0.0030	0.050	0.0470	0.037	0.0335	0.019	0.0100
June 05	0.059	0.0245	0.033	0.0100	0.111	0.0945	0.046	0.0440	0.025	0.0085
11	0.440	0.0965								
24	0.057	0.0410	0.021	0.0095	0.058	0.0500	0.042	0.0350	0.051	0.0140
July 02	0.064	0.0415	0.020	0.0075			0.027	0.0235	0.008	0.0035
11	0.228	0.5700								
16	0.465	0.0965								
19	1.390	0.2270								
21	0.605	0.1150								
Aug 07	0.053	0.0185					1.510	0.2420	0.122	0.1010
08	0.590	0.2090								
10	0.458	0.1540								
Sept 03	0.037	0.0085	0.006	0.0035			0.020	0.0195	0.003	0.0030
10	0.715	0.1120								
12	0.348	0.1120								
13	0.164	0.0700								
14	0.100	0.0495								
15	0.102	0.0600								
18			0.016	0.0115	0.033	0.0340	0.016	0.0120	0.019	0.0130
Oct 05	0.138	0.0725								
13	0.133	0.0585								
Nov 05	0.012	0.0040	0.002	0.0030	0.084	0.0830	0.039	0.0310	0.015	0.0075
18	0.010	0.0005	0.011	0.0025			0.133	0.0755	0.018	0.0085
Dec 17	0.051	0.0120								
18	0.162	0.0465								
18	0.156	0.0445								
19	0.084	0.0390								
19	0.079	0.0345								
19	0.067	0.0305								
19	0.046	0.0280								

TABLE D3 GROUNDWATER ATRAZINE CONCENTRATIONS 84-86 (ug/l)

		P1			P2			P3		
Piezometer Depth (m)		**1.2**	**1.8**	**2.4**	**1.2**	**1.8**	**2.4**	**1.2**	**1.8**	**2.4**
1984:										
Sept.	21	N.D.	N.D.	0.06	-	0.32	N.D.			
Oct.	11	N.D.	N.D.	N.D.	-	-	N.D.			
	19	N.D.	N.D.	N.D.	-	-	N.D.			
Nov.	1	0.03	N.D.	N.D.	-	-	N.D.			
	17	N.D.	N.D.	N.D.	-	0.22	0.10			
	30	N.D.	N.D.	N.D.	-	0.08	0.18			
Dec.	12	N.D.	0.06	N.D.	-	0.12	0.06			
	21	N.D.	N.D.	N.D.	-	N.D.	N.D.			
1985:										
April	22	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.			
May	16	-	N.D.	N.D.	-	-	N.D.			
	22	-	N.D.	N.D.	-	-	N.D.			
	28	-	N.D.	N.D.	-	-	N.D.			
June	7	-	N.D.	N.D.	-	-	N.D.			
								installed July 3		
July	19	-	0.13	N.D.	-	0.41	0.26	-	4.2	210.0
Aug.	5	-	0.05	0.05	-	-	0.08	-	-	42.0
	17	-	N.D.	N.D.	-	-	N.D.	-	-	14.0
Sept.	2	0.22	0.09	0.07	-	-	0.11	0.46	0.31	7.7
	25	N.D.	N.D.	N.D.	-	-	-	-	N.D.	5.3
Oct.	30	0.11	N.D.	N.D.	-	0.10	N.D.	-	0.07	1.5
Nov.	14	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	4.3

TABLE D3: **GROUNDWATER ATRAZINE CONCENTRATIONS 84-86 (ug/l) (cont'd)**

Piezometer Depth (m)		P1			P2			P3		
		1.2	1.8	2.4	1.2	1.8	2.4	1.2	1.8	2.4
1986:										
April	8	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-	N.D.	1.0
May	1	N.D.	N.D.	N.D.	-	N.D.	N.D.	-	N.D.	0.31
	21	N.D.	N.D.	N.D.	-	0.09	0.03	0.13	0.03	0.53
June	24	N.D.	N.D.	N.D.	-	-	N.D.	-	0.08	0.79
Aug.	11	N.D.	N.D.	N.D.	-	-	N.D.	-	0.05	0.82
Sept.	18	N.D.	N.D.	N.D.	-	N.D.	N.D.	-	N.D.	0.26
Oct.	20	N.D.	N.D.	N.D.	-	N.D.	N.D.	-	N.D.	0.11
Dec.	19	-	-	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

TABLE D4: TILE DRAIN ATRAZINE CONCENTRATIONS (ug/l), 1984-86

		T1	T2	T3	T4
1984:					
July	4				0.20
Aug.	2	2.6		1.3	0.095
	22	0.15		0.17	N.D.
Sept.	1	3.0		0.23	N.D.
	10	1.5		8.3	0.76
	21	1.8		2.7	0.13
Oct.	11	1.5		3.6	0.14
	19	1.6		3.5	0.28
Nov.	2	0.22		0.76	0.05
	17	0.59		1.1	0.42
	30	0.63	1.4	1.1	0.39
Dec.	12	0.81	1.7	1.8	1.1
	21	0.66	1.4	1.1	0.33
1985:					
Feb.	13				N.D.
	25				0.41
March	8				0.16
	29	0.60			0.70
April	22	0.71	1.4	1.9	0.22
May	2	1.8		4.1	0.60
	16	2.3		4.8	0.70
	22	1.2		2.4	0.50
	28	1.0		2.2	N.D.
June	7	0.87		2.00	N.D.
July	4	3.0		3.10	3.3
	19	3.2		1.90	1.7

TABLE D4 cont'd TILE DRAIN ATRAZINE CONCENTRATIONS (ug/l), 1984-86

		T1	T2	T3	T4
1985:					
Aug.	5			0.23	0.06
	17			N.D.	N.D.
Sept.	2	2.7		3.5	0.21
	25	1.8		1.8	N.D.
Oct.	30	1.3	2.6	1.6	0.51
Nov.	14	0.88	2.9	2.0	2.10
Dec.	10	0.49	1.9	0.69	0.62
1986:					
Feb.	24	0.46		0.83	0.42
March	4	0.53		1.10	N.D.
	19	0.55			2.20
April	8	0.42	2.20	0.72	0.59
May	1	0.43	1.90	0.77	0.38
	13	4.10	0.99	1.20	0.10
	26	0.71	2.00	1.20	0.59
June	5	0.96	1.90	1.50	0.75
	24	2.40	2.50	2.10	0.53
July	9	0.73	-	0.86	0.12
Aug.	7	-	-	3.90	2.10
Sept.	3	0.83	-	0.37	N.D.
	18	1.80	2.50	1.90	1.10
Nov.	5	0.88	85.0	1.70	0.93
	18	0.69	-	0.86	0.73

TABLE D5

MAXIMUM AND MINIMUM OBSERVED CONCENTRATIONS OF ATRAZINE, SUSPENDED SOLIDS AND TOTAL PHOSPHORUS IN TILE DRAIN SAMPLES, 1984-86

		Atrazine (ug/l)					Total Suspended Solids (mg/l)					Total Phosphorous (mg/l)				
Station	Year	Minimum	Sample Date	Maximum	Sample Date	# of Obs.	Minimum	Sample Date	Maximum	Sample Date	# of Obs.	Minimum	Sample Date	Maximum	Sample Date	# of Obs.
T1	84	0.15	Aug. 22	3.0	Sept. 1	12	0.012	Oct. 11	14.880	Dec. 12	12	0.008	Oct. 11	0.038	Dec. 12	12
	85	0.49	Dec. 10	3.2	July 19	14	0.402	Oct. 30	29.380	May 28	14	0.004	May 21	0.055	Sept. 2	13
	86	0.42	April 8	4.10	May 13	14	0.1	Sept. 18	100.500	March 19	13	0.002	Nov. 53	0.263	March 19	14
T2	84	1.40	Nov. 30	1.7	Dec. 12	3	0.800	Dec. 21	3.072	Dec. 12	3	0.013	Dec. 21	0.038	Dec. 12	3
	85	1.40	April 22	2.9	Nov. 14	4	-0.045	Oct. 30	7.080	April 22	4	0.026	Dec. 10	0.088	April 22	4
	86	0.99	May 13	85.0	Nov. 15	8	0.2	Nov. 5	2.6	June 5	8	0.033	April 8	0.220	May 13	8
T3	84	0.17	Aug. 22	8.3	Sept. 10	12	0.100	Oct. 11	14.900	Sept. 21	12	0.033	Nov. 2	0.840	Sept. 10	12
	85	ND	Aug. 19	4.80	May 16	15	-0.379	Sept. 2	7.340	April 22	15	0.017	Sept. 2	0.530	July 19	15
	86	0.37	Sept. 3	3.90	Aug. 7	14	0.047	March 4	625.0	Aug. 7	10	0.016	Sept. 18	1.51	Aug. 7	13
T4	84	ND	Nov. 2	1.10	Dec. 12	13	0.088	Oct. 11	8.060	Dec. 12	12	0.007	Aug. 22	1.400	Nov. 2	13
	85	ND	Feb. 14	3.3	July 4	19	-0.249	Aug. 5	15.280	March 29	16	0.002	Aug. 5	0.122	Feb. 25	21
	86	BD	March 5	2.20	March 19	15	0.9	May 12	18.730	March 19	11	0.003	Sept. 3	0.134	March 19	15

All measurements in ug/l

ND - not detected

Table D6 Observed Daily Total Suspended Solids, Total Phosphorus and Atrazine Loadings for Four Surface Water Monitoring Sites, 1985-86

Observed Daily Total Suspended Solids Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	***	***	***	***	***	122.8	***	***	***	***	***	***
2	***	***	***	***	2.1	***	***	***	10.4	***	***	***
3	***	***	***	***	***	***	***	***	***	***	***	***
4	***	***	***	***	***	***	24.2	***	***	***	***	***
5	***	***	***	***	***	***	***	47.8	4464.6	***	***	***
6	***	***	***	***	***	***	835.1	***	3481.5	***	***	***
7	***	***	***	***	***	5.6	609.6	***	***	***	***	***
8	***	***	27623.4	***	***	***	1364.6	***	***	***	***	***
9	***	***	***	***	***	104.8	***	***	***	***	***	***
10	***	***	***	***	***	***	***	***	***	***	***	71.5
11	***	***	***	***	***	286.4	***	***	***	***	***	***
12	***	***	***	***	***	424.9	17575.4	***	***	15877.0	***	***
13	***	5086.2	***	***	***	***	***	***	***	44003.5	***	***
14	***	***	***	***	***	***	***	***	***	25403.3	902.3	***
15	***	***	***	***	***	***	***	***	***	***	3120.8	***
16	***	***	***	***	63.2	690.4	***	***	***	***	3249.3	***
17	***	***	***	***	***	34445.4	***	25.9	***	***	3651.2	***
18	***	***	***	***	***	57483.5	***	***	***	9705.9	3989.4	***
19	***	***	***	***	***	7925.5	75.8	***	***	31929.5	5653.2	***
20	***	***	***	***	***	***	***	***	***	11447.9	***	***
21	***	2011.0	***	***	319.2	***	***	***	***	4332.4	***	***
22	***	65475.0	***	148.9	199.3	6853.1	***	***	***	***	***	***
23	***	***	***	***	***	7395.6	***	***	***	***	***	***
24	***	***	***	***	***	4583.3	***	3323.3	***	***	***	***
25	***	69952.8	***	***	***	***	***	3525.2	36.0	***	***	***
26	***	82604.3	***	***	235.7	***	***	24146.9	***	***	***	***
27	***	52306.7	***	***	515.9	***	***	***	***	***	***	***
28	***	***	***	***	352.3	***	***	***	***	***	***	***
29	***		9759.9	***	***	***	***	***	***	***	***	***
30	***		***	***	106.7	***	***	***	***	47.8	***	***
31	***		***		143.5		***	***		***		***

Observed Daily Total Suspended Solids Load, Stn. N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	***	***	***	***	***	60.4	***	***	***	***	***	***
2	***	***	***	***	24.6	***	***	***	1.6	***	***	***
3	***	***	***	***	***	***	***	***	***	***	***	***
4	***	***	***	***	***	***	2.3	***	***	***	***	***
5	***	***	***	***	***	***	***	2.0	144.0	***	***	***
6	***	***	***	***	***	***	140.2	***	83.4	***	***	***
7	***	***	***	***	***	10.1	119.6	***	***	***	***	***
8	***	***	7044.7	***	***	***	325.4	***	***	***	***	***
9	***	***	***	***	***	483.6	***	***	***	***	***	***
10	***	***	***	***	***	***	***	***	***	***	***	33.5
11	***	***	***	***	***	72.3	***	***	***	***	***	***
12	***	***	***	***	***	91.0	161.1	***	***	1694.2	***	***
13	***	907.2	***	***	***	***	***	***	***	4221.2	***	***
14	***	***	***	***	***	***	***	***	***	***	226.2	***
15	***	***	***	***	***	***	***	***	***	2007.3	348.8	***
16	***	***	***	***	9.6	856.1	***	***	***	***	360.8	***
17	***	***	***	***	***	887.5	***	6.0	***	***	381.1	***
18	***	***	***	***	***	1282.8	***	***	***	6774.5	377.8	***
19	***	***	***	***	***	410.9	19.5	***	***	7994.3	486.3	***
20	***	***	***	***	***	***	***	***	***	3015.1	***	***
21	***	88.5	***	***	***	***	***	***	***	***	***	***
22	***	***	***	15.5	***	302.2	***	***	***	***	***	***
23	***	***	***	***	***	273.5	***	***	***	***	***	***
24	***	***	***	***	***	135.6	***	232.1	***	***	***	***
25	***	13919.6	***	***	***	***	***	191.1	***	***	***	***
26	***	***	***	***	37.6	***	***	789.0	***	***	***	***
27	***	2572.5	***	***	315.1	***	***	***	***	***	***	***
28	***	***	***	***	87.9	***	***	***	***	***	***	***
29	***		2807.5	***	***	***	***	***	***	***	***	***
30	***		***	***	48.0	***	***	***	***	4.2	***	***
31	***		***		86.0		***	***		***		***

Observed Daily Total Suspended Solids Load, Stn. N3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	***	***	***	***	***	12.3	***	***	***	***	***	***
2	***	***	***	***	3.5	***	***	***	7.5	***	***	***
3	***	***	***	***	***	***	***	***	***	***	***	***
4	***	***	***	***	***	***	***	***	***	***	***	***
5	***	***	***	***	***	***	***	1.0	192.4	***	***	***
6	***	***	***	***	***	***	274.5	***	136.3	***	***	***
7	***	***	***	***	***	6.2	239.5	***	***	***	***	***
8	***	***	9266.8	***	***	***	648.0	***	***	***	***	***
9	***	***	***	***	***	52.3	***	***	***	***	***	***
10	***	***	***	***	***	***	***	***	***	***	***	***
11	***	***	***	***	***	41.7	***	***	***	***	***	***
12	***	***	***	***	***	45.2	202.8	***	***	761.9	***	***
13	***	393.9	***	***	***	***	***	***	***	2364.5	***	***
14	***	***	***	***	***	***	***	***	***	***	382.4	***
15	***	***	***	***	***	***	***	***	***	978.6	851.4	***
16	***	***	***	***	17.5	687.4	***	***	***	***	867.5	***
17	***	***	***	***	***	1127.9	***	2.1	***	***	965.6	***
18	***	***	***	***	***	981.8	***	***	***	362.8	1054.5	***
19	***	***	***	***	***	508.8	8.2	***	***	1730.4	1256.5	***
20	***	***	***	***	***	***	***	***	***	803.3	***	***
21	***	80.4	***	***	7.0	***	***	***	***	489.6	***	***
22	***	***	***	12.6	6.8	695.3	***	***	***	***	***	***
23	***	***	***	***	***	612.2	***	***	***	***	***	***
24	***	***	***	***	***	472.7	***	77.7	***	***	***	***
25	***	12106.1	***	***	***	***	***	73.3	1.2	***	***	***
26	***	***	***	***	30.7	***	***	252.1	***	***	***	***
27	***	3539.9	***	***	43.6	***	***	***	***	***	***	***
28	***	***	***	***	33.7	***	***	***	***	***	***	***
29	***		4575.9	***	***	***	***	***	***	***	***	***
30	***		***	***	11.6	***	***	***	***	8.1	***	***
31	***		***		14.1		***	***		***		***

Observed Daily Total Suspended Solids Load, Stn. N4, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	###	###	###	###	###	###	6.2	###	###	###	###	###
2	###	###	###	###	###	###	###	###	###	###	###	###
3	###	###	###	###	###	###	###	###	###	###	###	###
4	###	###	###	###	###	###	###	###	###	###	###	###
5	###	###	###	###	###	###	###	###	###	###	###	###
6	###	###	###	###	###	###	###	###	###	###	###	###
7	###	###	###	###	###	###	###	###	###	###	###	###
8	###	###	###	###	###	###	0.6	###	###	###	###	###
9	###	###	###	###	###	9.1	###	###	###	###	###	###
10	###	###	###	###	###	###	###	###	###	###	###	###
11	###	###	###	###	###	18.1	###	###	###	###	###	###
12	###	###	###	###	###	###	0.1	###	###	41.6	###	###
13	###	###	###	###	###	###	###	###	###	30.9	###	###
14	###	###	###	###	###	###	###	###	###	###	3.3	###
15	###	###	###	###	###	10.1	###	###	###	###	###	###
16	###	###	###	###	###	4.3	###	###	###	###	14.7	###
17	###	###	###	###	###	237.4	###	###	###	###	###	###
18	###	###	###	###	###	###	###	###	###	26.0	44.9	###
19	###	###	###	###	###	###	0.6	###	###	21.8	8.0	###
20	###	###	###	###	###	###	###	###	###	###	###	###
21	###	###	###	###	###	###	###	###	###	###	###	###
22	###	###	###	###	###	###	###	###	###	###	###	###
23	###	###	###	###	###	###	###	###	###	###	###	###
24	###	###	###	###	###	###	###	8.9	###	###	###	###
25	###	###	###	###	###	###	###	0.4	###	###	###	###
26	###	###	###	###	###	###	###	14.0	###	###	###	###
27	###	###	###	###	0.1	###	###	###	###	###	###	###
28	###	###	###	###	###	###	###	###	###	###	###	###
29	###		###	###	###	###	###	###	###	###	###	###
30	###		###	###	###	###	###	###	###	###	###	###
31	###		###		###		###	###		###		###

Observed Daily Total Suspended Solids Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	***	***	***	***	40.3	***	***	***	***	***	***	***
2	***	***	***	***	***	***	***	***	***	***	***	***
3	***	***	***	***	***	***	***	***	34.1	3213.0	***	***
4	***	***	21.2	***	***	***	***	***	***	8069.0	***	***
5	***	***	***	***	***	47.3	***	***	***	7309.0	221.0	***
6	***	***	***	***	***	***	***	***	***	***	***	***
7	***	***	***	***	***	***	***	4141.0	***	***	***	***
8	***	***	***	73.4	***	***	***	7611.0	***	***	***	***
9	***	***	***	***	***	***	38.3	8472.0	***	***	***	***
10	***	***	15068.0	***	***	***	***	4074.0	6704.0	***	***	***
11	***	***	30114.0	***	***	1746.0	211.0	3211.0	21383.0	***	***	***
12	***	42.2	6118.0	***	***	17981.0	1723.0	***	16433.0	186.4	***	***
13	***	***	1710.0	***	69.9	6575.0	1438.0	***	3944.0	1458.0	***	***
14	***	***	***	***	***	***	***	***	1487.0	2243.0	***	***
15	***	***	***	***	***	***	***	***	1550.0	1345.0	***	***
16	***	***	***	***	***	***	3921.0	***	2300.0	949.0	***	***
17	***	***	***	***	***	***	2917.0	***	1457.0	***	***	218.0
18	***	***	2571.0	***	***	***	3116.0	***	633.0	***	146.0	4246.0
19	***	***	16601.0	***	***	***	30748.0	***	***	***	***	1139.0
20	***	***	5429.0	645.8	4356.0	***	7109.0	***	***	***	***	***
21	***	***	1656.0	3297.0	2298.0	***	4331.0	***	***	***	***	***
22	***	***	***	1534.0	785.0	***	2501.0	***	***	***	***	***
23	***	***	***	***	***	***	***	***	***	***	***	***
24	***	103.9	***	***	***	46.3	***	***	***	***	***	***
25	***	***	***	***	***	***	***	***	***	***	***	***
26	***	***	***	***	68.9	***	***	***	***	***	***	***
27	***	***	***	***	***	***	***	***	***	***	***	***
28	***	***	***	***	***	***	***	***	***	***	***	***
29	***		***	***	***	***	***	***	***	***	***	***
30	***		***	***	***	***	***	***	***	***	***	***
31	***		***		***		***	***		***		***

Observed Daily Total Suspended Solids Load, Stn. N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	***	***	***	***	21.3	***	***	***	***	***	***	***
2	***	***	***	***	***	***	***	***	***	***	***	***
3	***	***	***	***	***	***	***	***	4.2	***	***	***
4	***	***	***	***	***	***	***	***	***	***	***	***
5	***	***	***	***	***	10.2	***	***	***	***	2.4	***
6	***	***	***	***	***	***	***	***	***	***	***	***
7	***	***	***	***	***	***	***	17.7	***	***	***	***
8	***	***	***	32.1	***	***	***	***	***	***	***	***
9	***	***	***	***	***	***	7.1	***	***	***	***	***
10	***	***	***	***	***	***	***	***	949.1	***	***	***
11	***	***	***	***	***	163.3	***	***	2017.0	***	***	***
12	***	***	***	***	***	1756.0	147.0	***	1671.0	***	***	***
13	***	***	***	***	9.3	201.3	***	***	807.0	114.0	***	***
14	***	***	***	***	***	***	***	***	373.5	152.0	***	***
15	***	***	***	***	***	***	***	***	756.0	94.0	***	***
16	***	***	***	***	***	***	130.0	***	983.0	67.5	***	***
17	***	***	***	***	***	***	53.7	***	680.0	***	***	***
18	***	***	***	***	***	***	237.4	***	***	***	0.4	218.5
19	***	***	***	***	***	***	942.0	***	***	***	***	53.0
20	***	***	***	130.8	1236.0	***	258.0	***	***	***	***	***
21	***	***	***	1060.0	356.0	***	133.0	***	***	***	***	***
22	***	***	***	484.0	113.0	***	21.4	***	***	***	***	***
23	***	***	***	***	***	***	***	***	***	***	***	***
24	***	***	***	***	***	9.4	***	***	***	***	***	***
25	***	***	***	***	***	***	***	***	***	***	***	***
26	***	***	***	***	32.3	***	***	***	***	***	***	***
27	***	***	***	***	***	***	***	***	***	***	***	***
28	***	***	***	***	***	***	***	***	***	***	***	***
29	***		***	***	***	***	***	***	***	***	***	***
30	***		***	***	***	***	***	***	***	***	***	***
31	***		***		***		***	***		***		***

Observed Daily Total Suspended Solids Load, Stn. N3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	###	###	###	###	10.8	###	###	###	###	###	###	###
2	###	###	###	###	###	###	###	###	###	###	###	###
3	###	###	###	###	###	###	###	###	10.0	###	###	###
4	###	###	###	###	###	###	###	###	###	###	###	###
5	###	###	###	###	###	13.1	###	###	###	###	7.6	###
6	###	###	###	###	###	###	###	###	###	###	###	###
7	###	###	###	###	###	###	###	7195.0	###	###	###	###
8	###	###	###	23.3	###	###	###	7329.0	###	###	###	###
9	###	###	###	###	###	###	6.8	2997.0	###	###	###	###
10	###	###	###	###	###	###	###	1469.0	46.0	###	###	###
11	###	###	###	###	###	76.1	24.0	967.0	226.0	###	###	###
12	###	###	###	###	###	391.0	74.6	###	349.9	###	###	###
13	###	###	###	###	7.8	204.0	23.2	###	164.4	###	###	###
14	###	###	###	###	###	###	###	###	94.2	###	###	###
15	###	###	###	###	###	###	###	###	267.6	###	###	###
16	###	###	###	###	###	###	123.0	###	426.6	###	###	###
17	###	###	###	###	###	###	42.0	###	224.8	###	###	###
18	###	###	###	###	###	###	###	###	63.9	###	50.0	167.2
19	###	###	###	###	###	###	###	###	###	###	###	46.5
20	###	###	###	84.1	442.3	###	###	###	###	###	###	###
21	###	###	###	354.0	261.4	###	###	###	###	###	###	###
22	###	###	###	184.3	39.9	###	###	###	###	###	###	###
23	###	###	###	###	###	###	###	###	###	###	###	###
24	###	###	###	###	###	10.4	###	###	###	###	###	###
25	###	###	###	###	###	###	###	###	###	###	###	###
26	###	###	###	###	14.3	###	###	###	###	###	###	###
27	###	###	###	###	###	###	###	###	###	###	###	###
28	###	###	###	###	###	###	###	###	###	###	###	###
29	###		###	###	###	###	###	###	###	###	###	###
30	###		###	###	###	###	###	###	###	###	###	###
31	###		###		###		###	###		###		###

Observed Daily Total Suspended Solids Load, Stn. N4, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1956/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	###	###	###	###	0.3	###	###	###	###	###	###	###
2	###	###	###	###	###	###	###	###	###	###	###	###
3	###	###	###	###	###	###	###	###	###	###	###	###
4	###	###	###	###	###	###	###	###	###	###	###	###
5	###	###	###	###	###	###	###	###	###	###	###	###
6	###	###	###	###	###	###	###	###	###	###	###	###
7	###	###	###	###	###	###	###	###	###	###	###	###
8	###	###	###	###	###	###	###	###	###	###	###	###
9	###	###	###	###	###	###	###	###	###	###	###	###
10	###	###	###	###	###	###	###	###	2.1	###	###	###
11	###	###	###	###	###	###	###	###	1.4	###	###	###
12	###	###	###	###	###	###	###	###	0.7	###	###	###
13	###	###	###	###	###	###	###	###	###	###	###	###
14	###	###	###	###	###	###	###	###	###	###	###	###
15	###	###	###	###	###	###	###	###	1.7	###	###	###
16	###	###	###	###	13.3	###	###	###	###	###	###	###
17	###	###	###	###	###	###	###	###	###	###	###	###
18	###	###	###	###	15.3	###	###	###	###	###	###	###
19	###	###	###	###	31.4	###	###	###	###	###	###	###
20	###	###	###	###	63.1	###	###	###	###	###	###	###
21	###	###	###	###	###	###	###	###	###	###	###	###
22	###	###	###	###	###	###	###	###	###	###	###	###
23	###	###	###	###	0.9	###	###	###	###	###	###	###
24	###	###	###	###	1.9	###	###	###	###	###	###	###
25	###	###	###	###	###	###	###	###	###	###	###	###
26	###	###	###	###	###	###	###	###	###	###	###	###
27	###	###	###	###	###	###	###	###	###	###	###	###
28	###	###	###	###	###	###	###	###	###	###	###	###
29	###		###	###	###	###	###	###	###	###	###	###
30	###		###	###	###	###	###	###	###	###	###	###
31	###		###		###		###	###		###		###

Observed Daily Total Phosphorus Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	####	0.62	####	####	####	####	####	####
2	####	####	####	####	0.16	####	####	####	0.02	####	####	####
3	####	####	####	####	####	####	####	####	####	####	####	####
4	####	####	####	####	####	####	0.28	####	####	####	####	####
5	####	####	####	####	####	####	####	0.15	0.36	####	####	####
6	####	####	####	####	####	####	2.05	####	0.28	####	####	####
7	####	####	####	####	####	0.09	1.50	####	####	####	####	####
8	####	####	108.00	####	####	####	3.35	####	####	####	####	####
9	####	####	####	####	####	0.55	####	####	####	####	####	####
10	####	####	####	####	####	####	####	####	####	####	####	1.50
11	####	####	####	####	####	0.54	####	####	####	####	####	####
12	0.45	####	####	####	####	0.64	42.80	####	####	29.26	####	####
13	####	21.20	####	####	####	####	####	####	####	80.90	####	####
14	####	####	####	####	####	####	####	####	####	46.80	9.44	####
15	####	####	####	####	####	####	####	####	####	####	12.50	####
16	####	####	####	####	0.09	5.96	####	####	####	####	13.00	####
17	####	####	####	####	####	117.50	####	0.25	####	####	14.70	####
18	####	####	####	####	####	64.50	####	####	####	39.40	16.00	####
19	####	####	####	####	####	12.30	0.50	####	####	13.10	22.70	####
20	####	####	####	####	####	####	####	####	####	17.20	####	####
21	####	4.42	####	####	1.04	####	####	####	####	7.97	####	####
22	####	144.00	####	0.95	0.65	10.30	####	####	####	####	####	####
23	####	####	####	####	####	11.20	####	####	####	####	####	####
24	####	####	####	####	####	6.91	####	7.20	####	####	####	####
25	####	244.00	####	####	####	####	####	7.64	0.27	####	####	####
26	####	130.00	####	####	0.55	####	####	52.30	####	####	####	####
27	####	82.60	####	####	1.20	####	####	####	####	###-	####	####
28	####	####	####	####	0.82	####	####	####	####	####	####	####
29	####		46.90	####	####	####	####	####	####	####	####	####
30	####		####	####	####	####	####	####	####	0.21	####	####
31	####		####		0.72		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	####	0.17	####	####	####	####	####	####
2	####	####	####	####	0.07	####	####	####	0.06	####	####	####
3	####	####	####	####	####	####	####	####	####	####	####	####
4	####	####	####	####	####	####	0.03	####	####	####	####	####
5	####	####	####	####	####	####	####	0.01	0.14	####	####	####
6	####	####	####	####	####	####	0.27	####	0.08	####	####	####
7	####	####	####	####	####	0.05	0.23	####	####	####	####	####
8	####	####	####	####	####	####	0.62	####	####	####	####	####
9	####	####	####	####	####	0.39	####	####	####	####	####	####
10	####	####	####	####	####	####	####	####	####	####	####	0.55
11	####	####	####	####	####	0.18	####	####	####	####	####	####
12	0.08	####	####	####	####	0.23	0.35	####	####	2.89	####	####
13	####	2.05	####	####	####	####	####	####	####	8.15	####	####
14	####	####	####	####	####	####	####	####	####	####	1.82	####
15	####	####	####	####	####	####	####	####	####	3.88	1.37	####
16	####	####	####	####	0.04	0.28	####	####	####	####	1.41	####
17	####	####	####	####	####	1.95	####	0.02	####	####	1.49	####
18	####	####	####	####	####	11.80	####	####	####	9.97	1.48	####
19	####	####	####	####	####	1.89	0.08	####	####	14.00	1.90	####
20	####	####	####	####	####	####	####	####	####	4.69	####	####
21	####	0.20	####	####	0.04	####	####	####	####	####	####	####
22	####	####	####	0.08	0.04	0.70	####	####	####	####	####	####
23	####	####	####	####	####	0.63	####	####	####	####	####	####
24	####	####	####	####	####	0.93	####	0.57	####	####	####	####
25	####	62.00	####	####	####	####	####	0.47	0.03	####	####	####
26	####	####	####	####	0.05	####	####	1.95	####	####	####	####
27	####	21.00	####	####	0.49	####	####	####	####	####	####	####
28	####	####	####	####	0.13	####	####	####	####	####	####	####
29	####		20.30	####	####	####	####	####	####	####	####	####
30	####		####	####	0.14	####	####	####	####	0.08	####	####
31	####		####		0.24		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	####	0.10	####	####	####	####	####	####
2	####	####	####	####	0.03	####	####	####	0.13	####	####	####
3	####	####	####	####	####	####	####	####	####	####	####	####
4	####	####	####	####	####	####	####	####	####	####	####	####
5	####	####	####	####	####	####	####	0.01	0.05	####	####	####
6	####	####	####	####	####	####	0.89	####	0.04	####	####	####
7	####	####	####	####	####	0.06	0.77	####	####	####	####	####
8	####	####	33.60	####	####	####	2.10	####	####	####	####	####
9	####	####	####	####	####	0.51	####	####	####	####	####	####
10	####	####	####	####	####	####	####	####	####	####	####	0.46
11	####	####	####	####	####	0.16	####	####	####	####	####	####
12	0.08	####	####	####	####	0.18	0.31	####	####	2.26	####	####
13	####	2.18	####	####	####	####	####	####	####	7.02	####	####
14	####	####	####	####	####	####	####	####	####	####	2.69	####
15	####	####	####	####	####	####	####	####	####	2.91	2.54	####
16	####	####	####	####	0.11	1.56	####	####	####	####	2.59	####
17	####	####	####	####	####	3.01	####	0.04	####	####	2.82	####
18	####	####	####	####	####	3.76	####	####	####	1.24	3.15	####
19	####	####	####	####	####	1.59	0.07	####	####	5.91	3.75	####
20	####	####	####	####	####	####	####	####	####	2.74	####	####
21	####	0.33	####	####	0.09	####	####	####	####	1.67	####	####
22	####	####	####	0.17	0.09	8.54	####	####	####	####	####	####
23	####	####	####	####	####	7.52	####	####	####	####	####	####
24	####	####	####	####	####	5.80	####	0.89	####	####	####	####
25	####	45.70	####	####	####	####	####	0.84	0.08	####	####	####
26	####	####	####	####	0.15	####	####	2.89	####	####	####	####
27	####	7.52	####	####	0.21	####	####	####	####	####	####	####
28	####	####	####	####	0.16	####	####	####	####	####	####	####
29	####		23.10	####	####	####	####	####	####	####	####	####
30	####		####	####	0.10	####	####	####	####	0.24	####	####
31	####		####		0.12		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N4, (GM)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	####	####	8.80	####	####	####	####	####
2	####	####	####	####	####	####	####	####	####	####	####	####
3	####	####	####	####	####	####	####	####	####	####	4.21	####
4	####	####	####	####	####	####	####	####	####	####	11.98	####
5	####	####	####	####	####	####	####	####	####	####	7.99	####
6	####	####	####	####	####	####	####	####	####	####	####	####
7	####	####	####	####	####	####	####	####	####	####	1.96	####
8	####	####	####	####	####	####	3.57	####	####	####	####	####
9	####	####	####	####	####	8.50	####	####	####	####	15.30	####
10	####	####	####	####	####	####	####	####	####	####	19.98	####
11	####	####	####	####	####	17.00	####	####	####	####	####	####
12	####	####	####	####	####	####	0.25	####	####	51.60	####	####
13	####	####	####	####	####	####	####	####	####	38.40	9.15	####
14	####	####	####	####	####	####	####	####	####	####	1.98	####
15	####	####	####	####	####	128.00	####	####	####	####	####	####
16	####	####	####	####	####	55.00	####	####	####	####	25.64	####
17	####	####	####	####	####	3182.00	####	####	####	####	####	####
18	####	####	####	####	####	####	####	####	####	30.80	77.60	####
19	####	####	####	####	####	####	1.09	####	####	45.00	####	####
20	####	####	####	####	####	####	####	####	####	####	####	####
21	####	####	####	####	####	####	####	####	####	####	####	####
22	####	####	####	####	####	####	####	####	####	####	####	####
23	####	####	####	####	####	####	####	####	####	####	####	####
24	####	####	####	0.04	####	####	####	2.08	####	####	####	####
25	####	####	####	####	####	####	####	0.10	####	####	####	####
26	####	####	####	####	####	####	####	3.28	####	####	####	####
27	####	####	####	####	0.56	####	####	####	####	####	####	####
28	####	####	####	####	####	####	####	####	####	####	####	####
29	####		####	####	####	####	####	####	####	####	####	####
30	####		####	####	####	####	####	####	####	####	####	####
31	####		####		0.10		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	0.32	####	####	####	####	####	####	####
2	####	####	####	####	####	####	####	####	####	####	####	####
3	####	####	####	####	####	####	####	####	0.26	7.97	####	####
4	####	####	0.54	####	####	####	####	####	####	17.60	####	####
5	####	####	####	####	####	0.53	####	####	####	16.00	0.28	####
6	####	####	####	####	####	####	####	####	####	####	####	####
7	####	####	####	####	####	####	####	12.02	####	####	####	####
8	####	####	####	0.56	####	####	####	20.87	####	####	####	####
9	####	####	####	####	####	####	0.40	22.60	####	####	####	####
10	####	####	40.60	####	####	####	####	10.80	15.71	####	####	####
11	####	####	94.30	####	####	2.35	0.52	8.55	47.80	####	####	####
12	####	0.80	21.50	####	####	23.20	3.54	####	31.85	1.32	####	####
13	####	####	7.90	####	0.13	8.69	2.96	####	9.76	10.80	####	####
14	####	####	####	####	####	####	####	####	4.20	16.60	####	####
15	####	####	####	####	####	####	####	####	4.38	9.94	####	####
16	####	####	####	####	####	####	7.50	####	6.14	7.02	####	####
17	####	####	####	####	####	####	5.58	####	3.89	####	####	1.24
18	####	####	11.60	####	####	####	4.87	####	1.98	####	0.18	10.20
19	####	####	194.00	####	####	####	48.60	####	####	####	####	5.06
20	####	####	21.70	2.84	12.70	####	13.40	####	####	####	####	####
21	####	####	7.21	13.70	8.98	####	8.16	####	####	####	####	####
22	####	####	####	7.77	3.29	####	4.77	####	####	####	####	####
23	####	####	####	####	####	####	####	####	####	####	####	####
24	####	0.68	####	####	####	0.61	####	####	####	####	####	####
25	####	####	####	####	####	####	####	####	####	####	####	####
26	####	####	####	####	0.79	####	####	####	####	####	####	####
27	####	####	####	####	####	####	####	####	####	####	####	####
28	####	####	####	####	####	####	####	####	####	####	####	####
29	####		####	####	####	####	####	####	####	####	####	####
30	####		####	####	####	####	####	####	####	####	####	####
31	####		####		####		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	0.18	####	####	####	####	####	####	####
2	####	####	####	####	####	####	####	####	####	####	####	####
3	####	####	####	####	####	####	####	####	0.03	####	####	####
4	####	####	####	####	####	####	####	####	####	####	####	####
5	####	####	####	####	####	0.09	####	####	####	####	0.27	####
6	####	####	####	####	####	####	####	####	####	####	####	####
7	####	####	####	####	####	####	####	0.21	####	####	####	####
8	####	####	####	0.19	####	####	####	####	####	####	####	####
9	####	####	####	####	####	####	0.03	####	####	####	####	####
10	####	####	####	####	####	####	####	####	2.37	####	####	####
11	####	####	####	####	####	0.45	####	####	5.68	####	####	####
12	####	####	####	####	####	4.79	0.76	####	5.90	####	####	####
13	####	####	####	####	0.04	0.92	####	####	2.42	3.36	####	####
14	####	####	####	####	####	####	####	####	1.16	4.48	####	####
15	####	####	####	####	####	####	####	####	2.00	2.77	####	####
16	####	####	####	####	####	####	0.39	####	2.53	1.99	####	####
17	####	####	####	####	####	####	0.20	####	1.75	####	####	####
18	####	####	####	####	####	####	0.69	####	####	####	0.25	1.68
19	####	####	####	####	####	####	2.55	####	####	####	####	0.92
20	####	####	####	0.58	5.46	####	0.82	####	####	####	####	####
21	####	####	####	4.36	2.41	####	0.43	####	####	####	####	####
22	####	####	####	2.06	0.83	####	0.13	####	####	####	####	####
23	####	####	####	####	####	####	####	####	####	####	####	####
24	####	####	####	####	####	0.11	####	####	####	####	####	####
25	####	####	####	####	####	####	####	####	####	####	####	####
26	####	####	####	####	0.31	####	####	####	####	####	####	####
27	####	####	####	####	####	####	####	####	####	####	####	####
28	####	####	####	####	####	####	####	####	####	####	####	####
29	####		####	####	####	####	####	####	####	####	####	####
30	####		####	####	####	####	####	####	####	####	####	####
31	####		####		####		####	####		####		####

Observed Daily Total Phosphorus Load, Stn. N3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	****	****	****	****	0.12	****	****	****	****	****	****	****
2	****	****	****	****	****	****	****	****	****	****	****	****
3	****	****	****	****	****	****	****	****	0.09	****	****	****
4	****	****	****	****	****	****	****	****	****	****	****	****
5	****	****	****	****	****	0.15	****	****	****	****	0.09	****
6	****	****	****	****	****	****	****	****	****	****	****	****
7	****	****	****	****	****	****	****	14.35	****	****	****	****
8	****	****	****	0.13	****	****	****	16.45	****	****	****	****
9	****	****	****	****	****	****	0.12	8.41	****	****	****	****
10	****	****	****	****	****	****	****	4.12	0.61	****	****	****
11	****	****	****	****	****	0.44	0.18	2.74	3.00	****	****	****
12	****	****	****	****	****	2.18	0.47	****	4.51	****	****	****
13	****	****	****	****	0.09	1.14	0.18	****	1.64	****	****	****
14	****	****	****	****	****	****	****	****	0.94	****	****	****
15	****	****	****	****	****	****	****	****	1.52	****	****	****
16	****	****	****	****	****	****	0.52	****	2.03	****	****	****
17	****	****	****	****	****	****	0.23	****	1.07	****	****	****
18	****	****	****	****	****	****	****	****	0.38	****	0.12	1.58
19	****	****	****	****	****	****	****	****	****	****	****	0.74
20	****	****	****	0.39	2.57	****	****	****	****	****	****	****
21	****	****	****	1.39	1.25	****	****	****	****	****	****	****
22	****	****	****	0.77	0.34	****	****	****	****	****	****	****
23	****	****	****	****	****	****	****	****	****	****	****	****
24	****	****	****	****	****	0.16	****	****	****	****	****	****
25	****	****	****	****	****	****	****	****	****	****	****	****
26	****	****	****	****	0.20	****	****	****	****	****	****	****
27	****	****	****	****	****	****	****	****	****	****	****	****
28	****	****	****	****	****	****	****	****	****	****	****	****
29	****		****	****	****	****	****	****	****	****	****	****
30	****		****	****	****	****	****	****	****	****	****	****
31	****		****		****		****	****		****		****

Observed Daily Total Phosphorus Load, Stn. N4, (GM)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	####	####	####	####	0.79	####	####	####	####	####	####	####
2	####	####	####	####	####	####	####	####	####	####	####	####
3	####	####	####	####	####	####	####	####	####	####	####	####
4	####	####	####	####	####	####	####	####	####	####	####	####
5	####	####	####	####	####	####	####	####	####	####	####	####
6	####	####	####	####	####	####	####	####	####	####	####	####
7	####	####	####	####	####	####	####	####	####	####	####	####
8	####	####	####	####	####	####	####	####	####	####	####	####
9	####	####	####	####	####	####	####	####	####	####	####	####
10	####	####	####	####	####	####	####	####	5.60	####	####	####
11	####	####	####	####	####	####	####	####	3.60	####	####	####
12	####	####	####	####	####	####	####	####	1.80	####	####	####
13	####	####	####	####	####	####	####	####	####	####	####	####
14	####	####	####	####	####	####	####	####	####	####	####	####
15	####	####	####	####	####	####	####	####	4.50	####	####	####
16	####	####	####	####	13.20	####	####	####	####	####	####	####
17	####	####	####	####	####	####	####	####	####	####	####	####
18	####	####	####	####	15.20	####	####	####	####	####	####	0.27
19	####	####	####	####	31.30	####	####	####	####	####	####	0.05
20	####	####	####	####	62.90	####	####	####	####	####	####	####
21	####	####	####	####	####	####	####	####	####	####	####	####
22	####	####	####	####	####	####	####	####	####	####	####	####
23	####	####	####	####	0.90	####	####	####	####	####	####	####
24	####	####	####	####	1.90	####	####	####	####	####	####	####
25	####	####	####	####	####	####	####	####	####	####	####	####
26	####	####	####	####	####	####	####	####	####	####	####	####
27	####	####	####	####	####	####	####	####	####	####	####	####
28	####	####	####	####	####	####	####	####	####	####	####	####
29	####		####	####	####	####	####	####	####	####	####	####
30	####		####	####	####	####	####	####	####	####	####	####
31	####		####		####		####	####		####		####

Observed Total Daily Atrazine Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	******	******	******	******	******	0.0060	******	******	******	******	******	******
2	******	******	******	******	0.0080	******	******	******	0.0080	******	******	******
3	0.0560	******	******	******	******	******	******	******	******	******	******	******
4	******	******	******	******	******	******	0.0170	******	******	******	******	******
5	******	******	******	******	******	******	******	0.0010	0.0120	******	******	******
6	******	******	******	******	******	******	0.1290	******	0.0100	******	******	******
7	******	******	******	******	******	0.0020	0.0940	******	******	******	******	******
8	******	******	0.0800	******	******	******	0.2110	******	******	******	******	******
9	******	******	******	******	******	0.0260	******	******	******	******	******	******
10	******	******	******	******	******	******	******	******	******	******	******	0.0190
11	******	******	******	******	******	0.0090	******	******	******	******	******	******
12	******	******	******	******	******	0.0130	0.2630	******	******	0.0390	******	******
13	******	0.1280	******	******	******	******	******	******	******	0.1070	******	******
14	******	******	******	******	******	******	******	******	******	0.0620	0.1540	******
15	******	******	******	******	******	******	******	******	******	******	0.0660	******
16	******	******	******	******	0.0140	1.9900	******	******	******	******	0.0680	******
17	******	******	******	******	******	0.9590	******	******	******	******	0.0770	******
18	******	******	******	******	******	2.4700	******	******	******	0.0820	0.0640	******
19	******	******	******	******	******	0.1190	0.0130	******	******	0.6380	0.1190	******
20	******	******	******	******	******	******	******	******	******	0.2560	******	******
21	******	0.0129	******	******	0.0100	******	******	******	******	0.1210	******	******
22	******	0.4190	******	0.0080	0.0060	0.1160	******	******	******	******	******	******
23	******	******	******	******	******	0.1250	******	******	******	******	******	******
24	******	******	******	******	******	0.0780	******	0.0290	******	******	******	******
25	******	******	******	******	******	******	******	0.0310	******	******	******	******
26	******	0.2360	******	******	0.0080	******	******	0.2110	******	******	**.***	******
27	******	0.1500	******	******	0.0170	******	******	******	******	******	******	******
28	******	******	******	******	0.0120	******	******	******	******	******	******	******
29	******		0.2540	******	******	******	******	******	******	******	******	******
30	******		******	******	******	******	******	******	******	0.0050	******	******
31	******		******		0.0070		******	******		******		******

Observed Total Daily Atrazine Load, Stn N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	******	******	******	******	******	0.0020	******	******	******	******	******	******
2	******	******	******	******	******	******	******	******	0.0005	******	******	******
3	******	******	******	******	******	******	******	******	******	******	******	******
4	******	******	******	******	******	******	0.0010	******	******	******	******	******
5	******	******	******	******	******	******	******	0.0001	0.0050	******	******	******
6	******	******	******	******	******	******	0.0090	******	0.0030	******	******	******
7	******	******	******	******	******	0.0003	0.0080	******	******	******	******	******
8	******	******	******	******	******	******	0.0210	******	******	******	******	******
9	******	******	******	******	******	0.0090	******	******	******	******	******	******
10	******	******	******	******	******	******	******	******	******	******	******	0.0060
11	******	******	******	******	******	******	******	******	******	******	******	******
12	******	******	******	******	******	******	0.0220	******	******	0.0090	******	******
13	******	******	******	******	******	******	******	******	******	0.0250	******	******
14	******	******	******	******	******	******	******	******	******	0.0140	0.0560	******
15	******	******	******	******	******	******	******	******	******	******	0.0170	******
16	******	******	******	******	0.0020	0.0640	******	******	******	******	0.0170	******
17	******	******	******	******	******	0.1520	******	******	******	******	0.0180	******
18	******	******	******	******	******	0.2520	******	******	******	0.0160	0.0180	******
19	******	******	******	******	******	0.0340	0.0030	******	******	0.0950	0.0230	******
20	******	******	******	******	******	******	******	******	******	0.0310	******	******
21	******	******	******	******	******	******	******	******	******	******	******	******
22	******	******	******	0.0010	0.0010	0.0350	******	******	******	******	******	******
23	******	******	******	******	******	0.0310	******	******	******	******	******	******
24	******	******	******	******	******	0.0160	******	0.0030	******	******	******	******
25	******	******	******	******	******	******	******	0.0030	******	******	******	******
26	******	******	******	******	0.0003	******	******	0.0110	******	******	******	******
27	******	******	******	******	0.0090	******	******	******	******	******	******	******
28	******	******	******	******	0.0010	******	******	******	******	******	******	******
29	******		0.0270	******	******	******	******	******	******	******	******	******
30	******		******	******	******	******	******	******	******	0.0010	******	******
31	******		******		0.0030		******	******		******		******

Observed Total Daily Atrazine Load, STN. NO3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	######	######	######	######	######	0.0007	######	######	######	######	######	######
2	######	######	######	######	######	######	######	######	0.0005	######	######	######
3	######	######	######	######	######	######	######	######	######	######	######	######
4	######	######	######	######	######	######	######	######	######	######	######	######
5	######	######	######	######	######	######	######	######	0.0030	######	######	######
6	######	######	######	######	######	######	0.0040	######	0.0020	######	######	######
7	######	######	######	######	######	######	0.0040	######	######	######	######	######
8	######	######	######	######	######	######	0.0100	######	######	######	######	######
9	######	######	######	######	######	######	######	######	######	######	######	######
10	######	######	######	######	######	######	######	######	######	######	######	0.0040
11	######	######	######	######	######	######	######	######	######	######	######	######
12	######	######	######	######	######	######	0.0020	######	######	0.0070	######	######
13	######	0.0030	######	######	######	######	######	######	######	0.0220	######	######
14	######	######	######	######	######	######	######	######	######	######	0.0460	######
15	######	######	######	######	######	######	######	######	######	0.0090	0.0230	######
16	######	######	######	######	0.0007	0.0450	######	######	######	######	0.0230	######
17	######	######	######	######	######	0.0940	######	######	######	######	0.0260	######
18	######	######	######	######	######	0.8200	######	######	######	0.0130	0.0280	######
19	######	######	######	######	######	0.3180	######	######	######	0.0600	0.0340	######
20	######	######	######	######	######	######	0.0006	######	######	0.0280	######	######
21	######	######	######	######	######	######	######	######	######	0.0170	######	######
22	######	######	######	0.0010	######	0.0720	######	######	######	######	######	######
23	######	######	######	######	######	0.0640	######	######	######	######	######	######
24	######	######	######	######	######	0.0490	######	0.0020	######	######	######	######
25	######	0.1450	######	######	######	######	######	0.0010	######	######	######	######
26	######	######	######	######	0.0040	######	######	0.0050	######	######	######	######
27	######	0.0910	######	######	0.0060	######	######	######	######	######	######	######
28	######	######	######	######	0.0050	######	######	######	######	######	######	######
29	######		0.0620	######	######	######	######	######	######	######	######	######
30	######		######	######	0.0007	######	######	######	######	0.0010	######	######
31	######		######		0.0008		######	######		######		######

Observed Total Daily AtraziNE LOAD, STN. N4, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

```
DAY      JAN     FEB     MAR     APR     MAY     JUN     JUL     AUG     SEP     OCT     NOV     DEC

  1   ######  ######  ######  ######  ######  ######  0.0030  ######  ######  ######  ######  ######
  2   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
  3   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
  4   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
  5   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######

  6   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
  7   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
  8   ######  ######  ######  ######  ######  ######  0.0020  ######  ######  ######  ######  ######
  9   ######  ######  ######  ######  ######  0.0001  ######  ######  ######  ######  ######  ######
 10   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######

 11   ######  ######  ######  ######  ######  0.0002  ######  ######  ######  ######  ######  ######
 12   ######  ######  ######  ######  ######  ######  0.0002  ######  ######  0.0001  ######  ######
 13   ######  ######  ######  ######  ######  ######  ######  ######  ######  0.0001  0.0001  ######
 14   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 15   ######  ######  ######  ######  ######  0.0030  ######  ######  ######  ######  ######  ######

 16   ######  ######  ######  ######  ######  0.0010  ######  ######  ######  ######  0.0001  ######
 17   ######  ######  ######  ######  ######  0.0620  ######  ######  ######  ######  ######  ######
 18   ######  ######  ######  ######  ######  ######  ######  ######  ######  0.0001  0.0002  ######
 19   ######  ######  ######  ######  ######  ######  0.0005  ######  ######  0.0001  ######  ######
 20   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######

 21   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 22   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 23   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 24   ######  ######  ######  ######  ######  ######  ######  0.0002  ######  ######  ######  ######
 25   ######  ######  ######  ######  ######  ######  ######  0.0002  ######  ######  ######  ######

 26   ######  ######  ######  ######  ######  ######  ######  0.0003  ######  ######  ######  ######
 27   ######  ######  ######  ######  0.0020  ######  ######  ######  ######  ######  ######  ######
 28   ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 29   ######          ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 30   ######          ######  ######  ######  ######  ######  ######  ######  ######  ######  ######
 31   ######          ######          0.0006          ######  ######          ######          ######
```

Observed Daily Total Atrazine Load, Stn. N1, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	######	######	######	######	0.0100	######	######	######	######	######	######	######
2	######	######	######	######	######	######	######	######	######	######	######	######
3	######	######	######	######	######	######	######	######	0.0020	0.1710	######	######
4	######	######	0.01[illegible]	######	######	######	######	######	######	0.3830	######	######
5	######	######	######	######	######	0.0060	######	######	######	0.3470	0.0120	######
6	######	######	######	######	######	######	######	######	######	######	######	######
7	######	######	######	######	######	######	######	0.0798	######	######	######	######
8	######	######	######	0.0120	######	######	######	0.1320	######	######	######	######
9	######	######	######	######	######	######	0.0060	0.1380	######	######	######	######
10	######	######	0.0849	######	######	######	######	0.0660	0.0495	######	######	######
11	######	######	0.2910	######	######	0.0246	0.0046	0.0520	0.1600	######	######	######
12	######	0.0140	0.1200	######	######	0.2360	0.0180	######	0.2070	0.0236	######	######
13	######	######	0.0855	######	0.0040	0.0892	0.0150	######	0.1070	0.1210	######	######
14	######	######	######	######	######	######	######	######	0.0500	0.1670	######	######
15	######	######	######	######	######	######	######	######	0.0610	0.1120	######	######
16	######	######	######	######	######	######	0.0500	######	0.0960	0.0790	######	######
17	######	######	######	######	######	######	0.0370	######	0.0610	######	######	######
18	######	######	0.1750	######	######	######	0.0362	######	0.0330	######	0.0100	######
19	######	######	0.5850	######	######	######	0.3110	######	######	######	######	######
20	######	######	0.2000	0.0421	0.1940	######	0.1020	######	######	######	######	######
21	######	######	0.0821	0.1900	0.1910	######	0.0620	######	######	######	######	######
22	######	######	######	0.1100	0.0500	######	0.0376	######	######	######	######	######
23	######	######	######	######	######	######	######	######	######	######	######	######
24	######	0.0110	######	######	######	0.0230	######	######	######	######	######	######
25	######	######	######	######	######	######	######	######	######	######	######	######
26	######	######	######	######	0.0190	######	######	######	######	######	######	######
27	######	######	######	######	######	######	######	######	######	######	######	######
28	######	######	######	######	######	######	######	######	######	######	######	######
29	######		######	######	######	######	######	######	######	######	######	######
30	######		######	######	######	######	######	######	######	######	######	######
31	######		######		######		######	######		######		######

Observed Daily Total Atrazine Load, Stn. N2, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	######	######	######	######	0.0020	######	######	######	######	######	######	######
2	######	######	######	######	######	######	######	######	######	######	######	######
3	######	######	######	######	######	######	######	######	######	######	######	######
4	######	######	######	######	######	######	######	######	######	######	######	######
5	######	######	######	######	######	0.0011	######	######	######	######	0.0012	######
6	######	######	######	######	######	######	######	######	######	######	######	######
7	######	######	######	######	######	######	######	0.0013	######	######	######	######
8	######	######	######	0.0021	######	######	######	######	######	######	######	######
9	######	######	######	######	######	######	0.0030	######	######	######	######	######
10	######	######	######	######	######	######	######	######	0.0154	######	######	######
11	######	######	######	######	######	0.0050	######	######	0.0322	######	######	######
12	######	######	######	######	######	0.0509	0.0065	######	0.0267	######	######	######
13	######	######	######	######	0.0004	0.0088	######	######	0.0164	0.0195	######	######
14	######	######	######	######	######	######	######	######	0.0244	0.0260	######	######
15	######	######	######	######	######	######	######	######	0.0208	0.0161	######	######
16	######	######	######	######	######	######	0.0030	######	0.0196	0.0115	######	######
17	######	######	######	######	######	######	0.0017	######	0.0136	######	######	######
18	######	######	######	######	######	######	0.0163	######	######	######	0.0018	######
19	######	######	######	######	######	######	0.0630	######	######	######	######	######
20	######	######	######	0.0039	0.0963	######	0.0234	######	######	######	######	######
21	######	######	######	0.0250	0.0364	######	0.0121	######	######	######	######	######
22	######	######	######	0.0124	0.0160	######	0.0021	######	######	######	######	######
23	######	######	######	######	######	######	######	######	######	######	######	######
24	######	######	######	######	######	0.0016	######	######	######	######	######	######
25	######	######	######	######	######	######	######	######	######	######	######	######
26	######	######	######	######	0.0050	######	######	######	######	######	######	######
27	######	######	######	######	######	######	######	######	######	######	######	######
28	######	######	######	######	######	######	######	######	######	######	######	######
29	######		######	######	######	######	######	######	######	######	######	######
30	######		######	######	######	######	######	######	######	######	######	######
31	######		######		######		######	######		######		######

Observed Daily Total Atrazine Load, Stn. N3, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	######	######	######	######	0.0011	######	######	######	######	######	######	######
2	######	######	######	######	######	######	######	######	######	######	######	######
3	######	######	######	######	######	######	######	######	######	######	######	######
4	######	######	######	######	######	######	######	######	######	######	######	######
5	######	######	######	######	######	0.0009	######	######	######	######	0.0020	######
6	######	######	######	######	######	######	######	######	######	######	######	######
7	######	######	######	######	######	######	######	0.0132	######	######	######	######
8	######	######	######	0.0018	######	######	######	0.0190	######	######	######	######
9	######	######	######	######	######	######	0.0003	0.0131	######	######	######	######
10	######	######	######	######	######	######	######	0.0064	0.0063	######	######	######
11	######	######	######	######	######	0.0054	0.0012	0.0046	0.0313	######	######	######
12	######	######	######	######	######	0.0276	0.0017	######	0.0464	######	######	######
13	######	######	######	######	0.0004	0.0144	0.0012	######	0.0142	######	######	######
14	######	######	######	######	######	######	######	######	0.0081	######	######	######
15	######	######	######	######	######	######	######	######	0.0090	######	######	######
16	######	######	######	######	######	######	0.0047	######	0.0106	######	######	######
17	######	######	######	######	######	######	0.0022	######	0.0056	######	######	######
18	######	######	######	######	######	######	######	######	0.0027	######	0.0013	######
19	######	######	######	######	######	######	######	######	######	######	######	######
20	######	######	######	0.0031	0.0176	######	######	######	######	######	######	######
21	######	######	######	0.0096	0.0130	######	######	######	######	######	######	######
22	######	######	######	0.0056	0.0077	######	######	######	######	######	######	######
23	######	######	######	######	######	######	######	######	######	######	######	######
24	######	######	######	######	######	0.0013	######	######	######	######	######	######
25	######	######	######	######	######	######	######	######	######	######	######	######
26	######	######	######	######	0.0015	######	######	######	######	######	######	######
27	######	######	######	######	######	######	######	######	######	######	######	######
28	######	######	######	######	######	######	######	######	######	######	######	######
29	######		######	######	######	######	######	######	######	######	######	######
30	######		######	######	######	######	######	######	######	######	######	######
31	######		######		######		######	######		######		######

Observed Daily Total Atrazine Load, Stn. N4, (KG)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	######	######	######	######	0.0002	######	######	######	######	######	######	######
2	######	######	######	######	######	######	######	######	######	######	######	######
3	######	######	######	######	######	######	######	######	######	######	######	######
4	######	######	######	######	######	######	######	######	######	######	######	######
5	######	######	######	######	######	######	######	######	######	######	######	######
6	######	######	######	######	######	######	######	######	######	######	######	######
7	######	######	######	######	######	######	######	0.0018	######	######	######	######
8	######	######	######	######	######	######	######	0.0006	######	######	######	######
9	######	######	######	######	######	######	######	######	######	######	######	######
10	######	######	######	######	######	######	######	######	0.0010	######	######	######
11	######	######	######	######	######	0.0032	######	######	0.0007	######	######	######
12	######	######	######	######	######	0.0132	0.0003	######	0.0003	######	######	######
13	######	######	######	######	######	######	0.0001	######	######	######	######	######
14	######	######	######	######	######	######	######	######	######	######	######	######
15	######	######	######	######	######	######	######	######	0.0008	######	######	######
16	######	######	######	######	######	######	0.0004	######	######	######	######	######
17	######	######	######	######	######	######	######	######	######	######	######	######
18	######	######	######	######	0.0001	######	0.0035	######	######	######	######	######
19	######	######	######	######	0.0001	######	######	######	######	######	######	######
20	######	######	######	######	0.0002	######	######	######	######	######	######	######
21	######	######	######	######	######	######	######	######	######	######	######	######
22	######	######	######	######	######	######	######	######	######	######	######	######
23	######	######	######	######	######	######	######	######	######	######	######	######
24	######	######	######	######	######	0.0026	######	######	######	######	######	######
25	######	######	######	######	######	######	######	######	######	######	######	######
26	######	######	######	######	######	######	######	######	######	######	######	######
27	######	######	######	######	######	######	######	######	######	######	######	######
28	######	######	######	######	######	######	######	######	######	######	######	######
29	######		######	######	######	######	######	######	######	######	######	######
30	######		######	######	######	######	######	######	######	######	######	######
31	######		######		######		######	######		######		######

APPENDIX E

METEOROLOGICAL DATA

Table E1 Daily Evaporation, Total Precipitation, Average Wind Speeds, Solar Radiation and Average Air Temperature, 1985-86

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                         Daily Evap. (mm/d) 1985-86

           ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY     JAN    FEB    MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

  1     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  2     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  3     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  4     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  5     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2

  6     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  7     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  8     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
  9     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 10     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2

 11     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 12     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 13     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 14     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 15     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2

 16     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 17     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 18     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 19     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 20     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2

 21     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 22     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 23     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 24     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 25     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2

 26     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 27     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 28     0.2    0.2    0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 29     0.2           0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 30     0.2           0.9    2.5    3.5    4.5    5.0    2.0    2.0    1.0    0.8    0.2
 31     0.2           0.9           3.5           5.0    2.0           1.0           0.2
SUM     6.8    5.6   27.9   75.0  108.5  135.0  155.0   62.0   60.0   31.0   24.0    6.2

SUM OF MONTHLY VALUES  6.97020e+02


                         Daily Evap. (mm/d) 1985-86

           ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY     JAN    FEB    MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

  1     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  2     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  3     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  4     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  5     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2

  6     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  7     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  8     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
  9     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 10     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2

 11     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 12     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 13     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 14     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 15     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2

 16     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 17     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 18     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 19     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 20     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2

 21     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.2
 22     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 23     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 24     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 25     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0

 26     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 27     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 28     0.2    0.2    0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 29     0.2           0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 30     0.2           0.9    2.0    3.0    4.5    5.2    3.8    3.7    1.0    0.8    0.0
 31     0.2           0.9           3.0           5.2    3.8           1.0           0.0
SUM     6.8    5.6   27.9   60.0   93.0  135.0  161.2  117.8  111.0   31.0   24.0    4.2

SUM OF MONTHLY VALUES  7.77520e+02
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Daily Total Precipitation Stn. TB 1 (mm)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	65.50	0.00	2.59	0.00	0.00	0.00	0.00	0.00	4.00	6.50	0.00	37.80
2	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.25	0.00	5.25	0.00
3	0.00	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.25	0.25	14.75	0.70
4	0.00	0.00	73.33	3.00	2.00	0.00	0.00	0.00	10.75	6.00	22.50	0.00
5	0.00	0.00	1.20	17.50	3.00	0.00	11.75	0.00	5.00	5.50	0.00	2.00
6	0.00	0.00	0.00	4.75	4.00	0.00	2.25	0.00	0.75	0.00	0.00	1.40
7	2.00	0.00	8.60	2.27	0.00	0.75	0.00	10.50	0.00	0.00	4.50	0.00
8	0.00	0.00	6.12	0.00	0.00	0.00	19.50	0.25	13.00	1.75	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	13.75	0.25	0.00	2.50	10.00	15.25	35.70
10	0.00	0.00	0.00	0.00	0.00	0.00	0.25	3.25	1.50	2.00	7.50	88.76
11	0.00	0.00	3.00	10.55	0.00	12.00	0.00	0.00	0.25	0.00	0.00	7.34
12	0.00	0.00	0.00	0.25	0.00	0.00	18.00	1.25	0.00	22.00	2.25	0.00
13	0.00	7.00	0.00	3.50	1.00	0.25	0.00	9.15	0.00	11.50	10.25	1.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.25	0.00	0.00	6.25	0.00
15	0.00	0.00	0.00	0.00	3.25	5.75	4.50	0.50	0.00	4.50	0.00	0.00
16	1.40	0.00	0.50	0.00	0.00	25.50	0.75	0.00	0.00	0.00	13.50	0.00
17	6.20	0.00	0.00	0.25	0.25	17.25	0.00	0.00	0.00	0.25	0.00	0.00
18	1.20	0.00	0.00	0.25	0.00	0.50	0.00	0.00	0.25	37.75	13.50	11.42
19	3.50	0.00	0.50	2.25	0.50	0.00	13.75	0.00	0.00	17.25	4.50	0.00
20	0.00	0.00	0.00	0.00	11.50	0.25	0.00	0.00	0.00	0.00	0.25	0.00
21	0.00	3.29	0.00	0.00	0.00	0.25	0.50	0.00	0.00	0.00	0.00	0.00
22	0.00	5.56	0.00	0.00	0.00	16.25	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	18.01	2.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	8.50	0.00
24	0.00	3.03	3.50	10.75	0.00	0.50	0.00	13.75	11.00	3.75	0.00	0.00
25	0.00	0.00	0.00	1.75	3.25	0.00	0.00	5.00	0.00	0.00	0.00	0.00
26	0.00	0.76	0.00	0.00	1.50	0.00	0.52	59.25	5.75	0.00	60.20	0.00
27	0.00	2.30	11.00	0.00	12.75	0.00	0.00	0.00	0.00	0.00	27.30	0.00
28	0.00	0.00	10.75	1.75	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	21.00	0.00
30	0.00		0.00	0.00	0.50	0.00	0.00	9.50	3.50	0.00	18.90	0.00
31	2.00		14.75		11.25		2.50	0.00		0.25		0.00
SUM	81.60	39.67	137.34	57.57	55.25	93.75	80.02	113.65	59.00	129.50	256.15	186.12

SUM OF MONTHLY VALUES 1.29013E+03

Daily Total Precipitation Stn. TB 2 (mm)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	65.50	0.00	2.59	0.00	0.00	0.00	0.00	0.00	4.00	4.25	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.25	0.00	5.25	0.00
3	0.00	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.25	0.00	15.00	0.00
4	0.00	0.00	73.33	3.00	1.50	0.00	0.00	0.00	10.75	4.00	16.25	0.00
5	0.00	0.00	1.20	11.50	2.25	0.00	10.50	0.00	5.00	4.50	0.75	2.70
6	0.00	0.00	0.00	4.75	3.75	0.00	0.75	0.00	0.75	0.00	0.00	2.70
7	2.00	0.00	8.60	2.27	0.00	0.50	1.25	7.00	0.25	0.00	4.50	0.00
8	0.00	0.00	6.12	0.00	0.00	0.00	22.00	0.25	10.50	1.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	12.75	0.25	0.00	2.25	7.50	15.25	35.70
10	0.00	0.00	0.00	0.00	0.00	0.00	0.25	3.25	3.50	1.75	7.50	88.76
11	0.00	0.00	3.00	10.27	0.00	12.00	0.00	0.00	0.00	0.00	0.00	7.34
12	0.00	0.00	0.00	0.25	0.00	0.00	10.25	0.00	0.00	16.75	0.50	0.00
13	0.00	7.00	0.00	0.50	1.00	0.25	0.00	7.00	0.00	11.00	12.25	1.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	3.00	0.00
15	0.00	0.00	0.00	0.00	3.75	17.20	0.25	8.83	0.00	3.00	0.25	0.00
16	1.40	0.00	0.50	0.00	0.00	7.38	0.00	0.00	0.00	0.00	13.50	0.00
17	6.20	0.00	0.00	0.25	0.25	29.82	0.00	0.00	0.00	0.00	0.00	0.00
18	1.20	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25	35.00	13.50	11.42
19	3.50	0.00	0.00	4.00	0.00	0.00	13.75	0.00	0.00	17.25	19.05	0.00
20	0.00	0.00	0.00	0.25	11.75	1.25	0.25	0.00	0.00	0.00	1.25	0.00
21	0.00	3.29	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	5.58	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	18.01	2.00	0.00	6.75	9.50	0.00	0.00	0.00	0.25	9.46	0.00
24	0.00	3.03	3.50	5.75	0.00	3.75	0.00	8.50	9.25	3.75	0.00	0.00
25	0.00	0.00	0.00	0.50	2.00	0.00	0.00	2.75	0.00	0.00	0.00	0.00
26	0.00	0.76	0.00	0.00	2.50	0.00	1.00	29.50	4.66	0.00	7.00	0.00
27	0.00	2.00	11.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	10.75	2.75	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	3.50	0.00
30	0.00		0.00	0.00	1.25	0.00	0.00	9.50	2.50	0.00	0.00	0.00
31	2.00		14.75		11.25		2.00	0.00		0.00		0.00
SUM	81.80	39.67	137.34	48.04	49.50	97.65	72.50	77.58	54.16	110.00	147.76	149.62

SUM OF MONTHLY VALUES 1.06569E+03

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                    Daily Total Precipitation Stn. TB 3 (mm)

             ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY      JAN     FEB     MAR     APR     MAY     JUN     JUL     AUG     SEP     OCT     NOV     DEC

  1    65.50    0.00    2.59    0.00    0.00    0.00    0.00    0.00    5.25    5.00    0.00    0.00
  2     0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    6.00    0.00
  3     0.00    0.00    0.00    1.75    0.00    0.00    0.00    0.00    0.00    0.00   11.00    0.00
  4     0.00    0.00   73.33    3.00    1.50    0.00    0.00    0.00    0.50    4.25   19.50    0.00
  5     0.00    0.00    1.20   17.50    2.25    0.00    7.50    0.00    3.25    2.75    0.00    2.70

  6     0.00    0.00    0.00    4.75    3.75    0.00    3.30    0.00    0.75    0.00    0.00    2.70
  7     2.00    0.00    8.60    2.27    0.00    0.25    0.50    6.25    0.00    0.00    4.00    0.00
  8     0.00    0.00    6.12    0.00    0.00    0.00   17.23    0.00   13.00    0.75    0.00    0.00
  9     0.00    0.00    0.00    0.00    0.00   13.75    0.41    0.00    2.50    7.25   17.75   35.70
 10     0.00    0.00    0.00    0.00    0.00    0.00    0.41    1.00    1.50    1.00    7.50   88.76

 11     0.00    0.00    3.00   10.55    0.00   14.12    0.00    0.00    0.25    0.00    0.00    7.34
 12     0.00    0.00    0.00    0.25    0.00    0.00   29.45    0.00    0.00   17.75    0.50    0.00
 13     0.00    7.00    0.00    0.50    1.00    0.29    0.00    0.50    0.00    7.75   12.25    1.00
 14     0.00    0.00    0.00    0.00    0.00    0.00    0.50    2.25    0.00    0.00    3.25    0.00
 15     0.00    0.00    0.00    0.00    3.89    3.50    4.75   17.50    0.00    3.50    0.00    0.00

 16     1.40    0.00    0.50    0.00    0.00   40.50    1.75    0.00    0.00    0.00   13.50    0.00
 17     6.20    0.00    0.00    0.25    0.00   14.75    0.00    0.00    0.00    0.00    0.00    0.00
 18     1.20    0.00    0.00    0.00    0.00    0.25    0.00    0.00    0.25   25.25   20.50   11.42
 19     3.50    0.00    0.00    4.00    0.00    0.00   15.23    0.00    0.00   14.50   19.05    0.00
 20     0.00    0.00    0.00    0.25   12.75    0.25    0.00    0.00    0.00    0.00    1.25    0.00

 21     0.00    3.29    0.00    0.25    0.00    0.00    0.50    0.00    0.00    0.00    0.00    0.00
 22     0.00    5.58    0.00    0.00    0.00   14.25    0.00    0.00    0.00    0.00    0.00    0.00
 23     0.00   18.01    2.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00   10.15    0.00
 24     0.00    3.03    3.50    5.75    0.00    0.51    0.00    6.00    8.00    2.50    0.00    0.00
 25     0.00    0.00    0.00    0.50    3.25    0.00    0.00    5.00    0.00    0.00    0.00    0.00

 26     0.00    0.76    0.00    0.00    2.00    0.00    1.00   58.75    5.75    0.00    7.00    0.00
 27     0.00    2.00   11.00    0.00   15.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
 28     0.00    0.00   10.75    2.75    0.50    0.00    0.00    0.00    0.00    0.00    0.00    0.00
 29     0.00            0.00    0.00    0.00    0.25    0.00    0.00    0.00    0.00    3.50    0.00
 30     0.00            0.00    0.00    0.00    0.00    0.00    7.25    2.00    0.00    0.00    0.00
 31     2.00           14.75           11.50            2.00    0.00            0.00            0.00
SUM    81.80   39.67  137.34   54.32   57.39  102.67   84.53  104.50   43.00   92.25  156.70  149.62

SUM OF MONTHLY VALUES 1.10379E+03
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Daily Total Precipitation Stn. TB 1 (mm)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	11.88	0.00	3.00	4.00	0.25	0.00	2.00	0.00	3.06	6.42	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.75	0.00	1.65	0.31	18.72
3	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.97	0.92	9.92
4	0.00	4.95	0.00	4.00	0.00	0.00	0.75	0.00	0.00	0.00	0.62	0.00
5	2.03	0.00	0.00	7.25	0.00	0.00	0.00	0.25	0.00	5.79	0.00	0.00
6	0.00	0.00	0.00	1.00	10.25	0.00	0.00	1.50	0.00	2.75	0.00	0.00
7	0.00	0.00	1.25	1.25	0.00	0.00	0.00	17.75	0.31	0.00	0.00	7.92
8	0.00	0.00	0.00	0.25	0.00	0.00	0.00	22.25	0.00	2.14	2.76	0.00
9	0.00	0.00	7.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.21
10	0.00	0.00	8.02	0.00	0.00	1.00	0.00	3.50	83.90	0.00	0.00	0.00
11	0.00	0.00	0.00	2.50	0.00	24.75	13.25	0.25	5.49	0.00	1.23	0.00
12	0.00	0.00	0.00	0.00	0.00	20.25	13.50	0.00	9.16	3.97	0.00	0.00
13	0.00	0.00	0.75	0.00	0.00	0.75	3.00	0.00	0.00	10.40	0.00	0.00
14	0.00	0.00	0.00	0.25	2.00	0.25	4.75	0.00	0.00	10.08	0.00	0.00
15	0.00	0.00	0.00	6.50	0.00	2.25	0.00	3.00	15.26	0.00	0.00	0.00
16	0.00	0.56	0.00	9.56	11.75	16.75	19.00	0.00	0.00	1.23	0.00	0.00
17	1.50	0.86	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	0.00
18	0.50	2.23	1.25	0.00	9.50	0.00	20.50	0.00	0.00	0.00	0.00	19.21
19	9.00	14.14	11.00	2.00	10.50	1.50	7.00	0.00	0.00	0.00	0.00	0.00
20	0.25	7.20	0.00	16.50	6.25	0.25	3.75	0.00	9.76	0.00	0.00	0.00
21	0.00	0.90	0.00	5.25	2.25	0.00	0.00	0.00	0.31	0.00	0.00	0.00
22	0.00	0.00	0.00	0.75	5.50	12.25	0.00	0.00	14.95	0.00	0.00	****
23	0.00	0.00	0.25	0.00	0.00	0.00	0.00	14.50	5.80	0.00	0.00	****
24	0.00	0.00	0.00	0.00	0.00	7.75	0.00	0.00	0.00	0.00	0.00	****
25	0.00	0.00	0.00	0.00	0.00	0.00	28.75	0.00	0.00	0.00	0.00	****
26	0.00	0.00	5.00	0.00	0.00	0.00	0.00	13.75	3.37	0.00	19.24	****
27	0.00	0.00	0.00	0.00	0.00	19.75	0.00	0.00	6.11	12.53	0.00	****
28	0.00	0.00	0.25	0.00	0.00	0.00	7.00	5.00	0.00	0.00	0.00	****
29	0.00		0.00	0.50	0.00	0.00	0.00	0.00	42.42	0.00	0.00	****
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	18.02	0.00	0.00	****
31	0.00		0.00		0.00		0.00	0.00		0.00		****
SUM	13.78	42.72	34.77	60.81	62.00	107.75	124.25	92.50	214.86	57.77	31.50	93.98

SUM OF MONTHLY VALUES 9.3669E+02

Daily Total Precipitation Stn. TB 2 (mm)

ANNUL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	11.88	0.00	2.75	3.25	0.50	0.00	0.00	0.00	2.50	5.13	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.75	0.00	2.00	0.25	17.06
3	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	6.48	1.01	6.30
4	0.00	4.95	3.30	1.50	0.00	0.00	0.50	0.00	0.00	9.16	0.50	0.00
5	2.03	0.00	0.00	5.97	0.00	5.00	0.00	6.00	0.00	5.14	0.00	0.00
6	0.00	0.00	0.00	1.50	10.25	0.00	0.00	0.51	0.00	0.51	0.00	0.00
7	0.00	0.00	1.25	0.25	0.00	1.50	0.00	28.45	0.00	0.00	0.00	6.50
8	0.00	0.00	0.00	0.00	0.00	1.02	0.00	19.01	0.00	5.16	2.56	0.00
9	0.00	0.00	7.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.50	31.34
10	0.00	0.00	8.02	0.25	0.00	2.56	0.00	3.25	47.69	0.00	0.00	0.00
11	0.00	0.00	0.00	1.00	0.00	17.52	4.00	0.00	20.02	0.00	1.03	0.00
12	0.00	0.02	0.00	0.00	0.00	17.50	15.51	0.00	8.25	3.33	0.00	0.00
13	0.00	0.00	0.75	0.00	0.00	0.25	6.02	0.00	0.25	8.15	0.00	0.00
14	0.00	0.00	0.00	0.00	2.75	0.00	3.75	0.00	0.00	8.48	0.00	0.00
15	0.00	0.00	0.00	6.50	0.75	1.75	0.00	2.25	16.51	0.25	0.00	0.00
16	0.00	0.56	0.00	9.81	11.00	6.50	12.75	0.00	0.00	1.06	0.00	0.00
17	1.50	0.86	0.00	0.00	0.00	0.00	3.23	0.00	0.00	0.25	0.00	0.00
18	0.50	2.23	1.25	0.00	9.50	0.00	22.14	0.00	0.00	0.00	0.00	15.70
19	9.00	14.14	11.00	0.00	10.02	0.75	0.00	0.00	0.00	0.00	0.00	0.00
20	0.25	7.25	0.00	11.00	17.00	0.25	5.75	0.00	2.98	0.00	0.00	0.00
21	0.00	0.90	0.00	7.25	0.00	0.00	0.00	0.00	0.00	0.00	2.95	0.00
22	0.00	0.00	0.00	0.28	2.76	6.75	0.00	0.00	8.75	0.00	0.00	####
23	0.00	0.00	0.25	0.00	3.50	0.00	0.00	6.75	4.76	0.00	0.50	####
24	0.00	0.00	0.00	0.00	0.00	7.03	0.00	0.30	0.00	0.00	0.00	####
25	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.36	0.00	0.00	####
26	0.00	0.00	2.00	0.00	0.00	0.00	22.75	6.51	2.75	0.76	17.52	####
27	0.00	0.00	1.75	0.00	0.00	15.25	0.00	0.00	5.00	10.77	0.00	####
28	0.00	0.00	0.00	0.00	0.00	0.00	8.50	3.26	0.25	0.25	0.00	####
29	0.00		0.00	0.25	0.00	0.00	0.50	0.00	34.75	0.51	0.00	####
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	14.76	0.00	0.00	####
31	0.00		0.00		0.00		0.00	0.00		0.00		####
SUM	13.78	42.72	33.27	48.31	70.78	86.13	107.68	86.04	167.08	64.76	31.94	78.90

SUM OF MONTHLY VALUES 8.29390E+02

Daily Total Precipitation Stn. TB 3 (mm)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.00	11.88	0.00	2.53	2.66	0.46	0.00	1.48	0.00	3.38	7.10	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.30	0.00	2.70	0.34	20.66
3	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.43	1.02	10.98
4	0.00	4.95	0.00	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00
5	2.03	0.00	0.00	8.53	0.00	5.84	0.00	5.52	0.00	6.41	0.00	0.00
6	0.00	0.00	0.00	0.59	7.66	0.00	0.00	0.47	0.00	3.04	0.00	0.00
7	0.00	0.00	1.25	0.29	0.00	0.00	0.00	25.22	0.00	0.00	0.00	8.78
8	0.00	0.00	0.00	0.00	0.00	4.42	0.00	18.58	0.00	2.37	3.05	0.00
9	0.00	0.00	7.00	0.00	0.00	0.00	0.23	0.29	0.00	0.00	0.00	42.32
10	0.00	0.00	8.02	0.00	0.00	0.59	0.00	2.34	64.37	0.00	0.00	0.00
11	0.00	0.00	0.00	1.47	0.00	16.32	3.68	0.00	11.05	0.00	1.36	0.00
12	0.00	0.00	0.00	0.00	0.00	22.72	14.27	0.00	12.75	4.49	0.00	0.00
13	0.00	0.00	0.75	0.00	0.00	0.59	5.54	0.00	0.00	11.00	0.00	0.00
14	0.00	0.00	0.00	0.29	2.06	0.00	3.45	0.00	0.00	11.46	0.00	0.00
15	0.00	0.00	0.00	7.95	0.59	1.47	0.00	1.19	0.00	0.00	0.00	0.00
16	0.00	0.56	0.00	10.31	11.48	5.98	22.46	0.00	0.00	1.44	0.00	0.00
17	1.50	0.86	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00
18	0.50	2.23	1.25	0.00	11.02	0.00	12.65	0.00	0.86	0.00	0.00	21.22
19	9.00	14.14	11.00	0.00	9.22	0.69	0.00	0.00	0.00	0.00	0.00	0.00
20	0.25	7.20	0.00	17.04	15.64	0.23	8.25	0.00	3.47	0.00	0.00	0.00
21	0.00	0.90	0.00	7.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	2.54	6.21	0.00	0.00	13.83	0.00	0.00	****
23	0.00	0.00	0.25	0.00	3.22	0.00	0.00	11.19	0.00	0.00	0.00	****
24	0.00	0.00	0.00	0.00	0.00	6.47	0.00	0.00	0.00	0.00	0.00	****
25	0.00	0.00	0.00	0.00	0.00	0.00	34.77	0.00	0.00	0.00	0.00	****
26	0.00	0.00	2.00	0.00	0.00	0.00	2.06	12.06	1.72	0.00	21.28	****
27	0.00	0.00	1.75	0.00	0.00	14.42	0.00	0.59	2.16	13.66	0.00	****
28	0.00	0.00	0.00	0.00	0.00	0.00	4.42	2.97	0.00	0 70	0.00	****
29	0.00		0.00	0.58	0.00	0.00	0.00	0.00	46.92	0.00	0.00	****
30	0.00		0.00	0.00	0.00	0.00	0.00	0.00	19.94	0.00	0.00	****
31	0.00		0.00		0.00		0.00	0.00		0.00		****
SUM	13.78	42.72	33.27	58.97	66.09	86.41	114.04	89.30	177.07	64.55	34.83	103.96

SUM OF MONTHLY VALUES 0.88499E+03

Daily Average Wind Speed (m/s)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.8	3.1	6.4	6.6	4.0	5.1	2.1	2.3	2.9	3.5	6.0	2.5
2	3.9	2.6	3.4	3.6	4.5	1.9	1.3	1.8	1.3	2.2	3.5	1.1
3	1.6	4.9	3.8	5.2	2.9	2.3	1.8	0.6	3.3	1.1	1.4	0.7
4	3.0	2.7	5.5	2.9	2.2	1.3	3.4	0.9	3.2	2.9	3.5	0.7
5	4.6	4.4	0.2	3.4	4.2	1.4	3.2	2.8	3.5	6.2	5.6	1.1
6	3.6	2.2	0.2	10.3	2.4	1.5	3.5	4.6	2.8	3.2	2.3	1.8
7	5.5	2.7	3.2	3.2	3.1	1.5	2.4	3.0	1.4	2.9	3.8	4.0
8	3.3	8.0	5.3	3.0	2.0	1.6	1.5	1.1	1.4	3.6	3.5	2.5
9	0.8	3.1	2.5	3.0	4.1	4.5	1.9	1.3	1.4	3.2	2.1	1.1
10	3.8	1.8	2.7	6.5	4.6	2.2	1.7	2.7	2.2	2.6	3.6	0.7
11	4.6	5.6	1.9	3.0	3.1	1.9	1.7	1.8	2.0	1.0	4.7	0.8
12	3.7	9.3	6.1	1.5	4.5	2.3	1.3	2.3	2.2	2.4	2.7	2.2
13	3.4	5.1	2.7	5.2	3.5	3.3	2.8	2.2	1.8	2.7	1.8	1.5
14	4.5	6.0	4.6	3.0	2.1	2.6	3.6	1.9	1.1	0.9	2.4	5.9
15	2.5	5.0	3.9	3.1	3.0	2.8	2.3	1.6	0.7	3.1	2.5	7.1
16	2.7	6.0	4.7	4.1	2.9	1.5	1.7	1.1	1.0	2.1	5.1	4.8
17	4.4	7.3	5.0	2.3	3.0	3.2	1.1	1.2	1.7	1.4	2.5	5.1
18	3.8	6.3	2.7	4.4	2.6	4.5	1.6	2.7	1.9	2.9	5.1	5.2
19	6.2	6.6	3.9	2.0	5.2	3.4	2.8	2.6	1.7	3.0	5.2	4.5
20	10.5	3.0	3.1	2.5	4.7	1.9	1.7	1.8	3.1	3.2	3.6	1.3
21	8.7	4.6	2.3	2.5	2.1	2.5	1.9	1.2	2.4	3.1	1.8	4.5
22	7.5	5.8	3.7	2.9	1.6	4.9	2.6	1.1	1.9	3.2	2.4	5.8
23	6.7	3.5	4.3	2.2	2.4	5.1	1.4	0.8	2.1	2.3	2.5	5.3
24	4.9	5.3	5.1	2.4	1.2	2.5	2.1	2.2	3.6	3.0	5.1	3.9
25	4.4	2.3	2.1	3.8	2.3	1.8	4.9	2.1	1.4	3.2	5.2	4.9
26	4.9	4.0	2.5	3.0	2.0	1.7	2.6	2.7	3.6	3.1	3.6	5.5
27	6.4	4.3	4.8	1.9	2.7	2.4	1.7	2.8	2.7	3.2	0.7	7.4
28	4.4	6.1	3.4	2.4	3.6	2.7	2.7	2.3	2.8	2.3	1.1	6.3
29	2.3		3.5	1.4	1.9	1.6	2.5	1.6	1.9	2.1	1.8	6.3
30	1.6		4.6	2.4	3.7	2.6	1.5	1.9	2.3	3.0	4.0	5.6
31	3.3		3.4		6.0		2.2	1.8		5.1		6.3

Daily Average Wind Speed (m/s)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	4.2	2.7	2.8	4.2	5.9	4.2	1.6	1.2	1.1	1.7	3.4	6.1
2	1.8	3.1	2.5	2.5	4.4	3.6	2.0	1.7	0.6	1.1	1.7	3.8
3	2.7	2.8	0.8	4.2	3.5	1.6	1.9	1.4	1.3	2.5	3.7	4.9
4	2.3	3.9	1.6	5.0	5.0	2.9	4.4	2.0	3.7	1.8	2.5	6.7
5	4.9	1.0	2.2	5.1	5.4	3.2	3.8	1.8	2.3	3.1	2.9	4.6
6	5.6	5.2	4.5	3.0	4.5	4.9	3.2	1.4	1.7	3.2	1.4	5.4
7	1.7	8.1	6.5	4.1	3.6	2.5	2.5	0.9	1.7	3.8	0.9	3.4
8	3.8	1.3	3.0	4.5	3.6	3.0	1.2	2.3	2.6	3.4	3.3	4.7
9	8.9	3.0	3.1	3.9	4.0	1.5	1.6	2.6	2.4	3.3	7.4	2.9
10	4.0	2.7	4.7	3.8	1.6	2.0	1.0	1.8	2.4	3.1	2.8	6.5
11	5.8	1.7	4.5	3.2	2.1	2.5	2.6	2.5	5.2	2.1	2.4	5.1
12	6.6	2.7	4.4	1.8	5.0	4.1	2.5	1.1	3.6	2.4	4.9	4.5
13	3.4	4.9	2.8	1.8	3.7	3.0	3.4	1.1	2.4	2.1	3.9	1.8
14	0.8	3.2	1.7	3.3	1.3	0.9	2.2	1.7	1.6	4.5	5.9	5.9
15	2.6	3.5	2.8	2.3	3.9	2.0	1.1	3.2	2.2	3.1	3.9	2.6
16	1.7	2.6	2.2	3.6	4.8	4.6	0.9	1.4	1.8	2.1	3.0	0.8
17	5.9	3.7	1.2	4.2	2.1	2.5	1.5	1.3	1.3	1.8	3.0	1.2
18	3.7	0.5	1.7	2.2	3.4	2.0	2.1	2.5	0.9	0.7	3.3	3.4
19	3.0	1.4	6.5	3.8	4.6	2.6	0.9	2.1	1.5	1.5	2.9	3.9
20	5.2	1.7	3.5	2.2	2.2	1.8	2.0	1.8	1.1	2.7	4.5	1.4
21	2.2	4.2	3.4	3.9	2.3	1.9	1.6	1.2	1.7	2.2	2.3	1.3
22	4.8	3.7	6.2	3.3	0.9	3.9	0.5	1.9	2.3	2.4	2.6	***
23	1.2	3.9	5.7	2.3	1.4	3.4	1.0	3.5	2.3	2.6	3.2	***
24	2.6	1.5	2.9	2.3	1.2	3.0	1.8	2.5	1.5	2.2	4.7	***
25	6.4	2.1	4.8	1.3	1.4	1.7	2.4	1.3	1.2	3.1	2.7	***
26	2.3	2.3	5.8	1.6	2.3	3.3	1.6	3.6	1.7	2.5	3.1	***
27	5.5	3.4	2.9	1.9	1.5	3.3	0.9	3.0	3.5	2.0	7.2	***
28	6.0	3.0	5.6	2.5	1.9	1.8	2.0	2.0	2.0	3.2	5.0	***
29	1.5		5.7	3.7	2.2	2.6	1.7	1.6	2.6	3.9	2.1	***
30	4.0		5.2	3.0	3.2	1.4	2.0	1.6	3.0	2.0	3.6	***
31	2.8		2.1		2.3		1.4	0.8		1.9		***

Daily Total Solar Radiation (langleys)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	6.0	140.0	230.0	116.0	341.0	597.0	360.0	554.0	416.0	270.0	198.0	34.0
2	52.0	150.0	274.0	358.0	539.0	576.0	296.0	622.0	510.0	339.0	46.0	36.0
3	148.0	278.0	316.0	176.0	610.0	658.0	660.0	597.0	394.0	342.0	17.0	52.0
4	178.0	260.0	30.0	254.0	302.0	610.0	578.0	561.0	141.0	276.0	24.0	79.0
5	130.0	146.0	222.0	168.0	246.0	442.0	448.0	343.0	252.0	58.0	78.0	48.0
6	30.0	194.0	392.0	122.0	178.0	671.0	362.0	238.0	170.0	220.0	51.0	104.0
7	12.0	236.0	172.0	448.0	571.0	596.0	442.0	362.0	293.0	279.0	22.0	76.0
8	176.0	226.0	275.0	404.0	642.0	608.0	391.0	573.0	232.0	121.0	136.0	34.0
9	112.0	254.0	402.0	442.0	570.0	480.0	571.0	585.0	192.0	131.0	12.0	36.0
10	82.0	230.0	392.0	374.0	560.0	666.0	601.0	444.0	107.0	44.0	18.0	52.0
11	154.0	94.0	138.0	472.0	505.0	114.0	655.0	587.0	441.0	280.0	49.0	16.0
12	30.0	72.0	132.0	108.0	524.0	534.0	580.0	511.0	342.0	55.0	47.0	92.0
13	176.0	110.0	200.0	392.0	654.0	442.0	580.0	417.0	397.0	137.0	40.0	80.0
14	130.0	206.0	359.0	428.0	624.0	638.0	325.0	355.0	446.0	148.0	15.0	134.0
15	110.0	222.0	366.0	492.0	164.0	378.0	322.0	104.0	441.0	208.0	181.0	79.0
16	154.0	224.0	394.0	542.0	305.0	238.0	566.0	552.0	449.0	235.0	23.0	84.0
17	106.0	246.0	274.0	439.0	425.0	314.0	617.0	577.0	384.0	236.0	181.0	119.0
18	106.0	284.0	466.0	400.0	474.0	485.0	650.0	300.0	253.0	211.0	23.0	134.0
19	122.0	298.0	364.0	210.0	600.0	500.0	315.0	495.0	407.0	211.0	23.0	152.0
20	126.0	300.0	418.0	444.0	308.0	686.0	569.0	269.0	411.0	288.0	49.0	118.0
21	154.0	226.0	448.0	482.0	656.0	640.0	354.0	308.0	140.0	272.0	15.0	164.0
22	134.0	82.0	398.0	468.0	574.0	274.0	660.0	349.0	337.0	256.0	181.0	56.0
23	114.0	56.0	126.0	416.0	644.0	640.0	643.0	401.0	302.0	280.0	23.0	78.0
24	124.0	80.0	168.0	284.0	650.0	695.0	617.0	179.0	418.0	211.0	181.0	122.0
25	146.0	188.0	494.0	372.0	570.0	670.0	576.0	370.0	387.0	288.0	23.0	188.0
26	208.0	164.0	464.0	393.0	222.0	696.0	509.0	285.0	65.0	272.0	23.0	144.0
27	112.0	292.0	200.0	558.0	210.0	686.0	604.0	409.0	368.0	256.0	79.0	18.0
28	158.0	438.0	114.0	480.0	762.0	646.0	518.0	380.0	400.0	280.0	48.0	154.6
29	164.0		322.0	582.0	688.0	442.0	502.0	133.0	389.0	258.0	104.0	112.0
30	190.0		314.0	581.0	480.0	623.0	489.0	127.0	244.0	128.0	76.0	112.0
31	136.0		22.0		232.0		107.0	524.0		218.0		68.0
SUM	3780.0	5696.0	8886.0	11405.0	14830.0	16245.0	15497.0	12493.0	9728.0	6778.0	1986.0	2875.0

Daily Total Solar Radiation (langleys)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	134.0	40.0	400.0	394.0	374.0	478.0	477.0	458.0	414.0	164.0	132.0	98.0
2	84.0	103.0	276.0	506.0	536.0	690.0	552.0	385.0	478.0	266.0	160.0	24.0
3	63.0	110.0	248.0	452.0	537.0	680.0	658.0	544.0	407.0	29.0	142.0	26.0
4	85.0	68.0	191.0	278.0	588.0	664.0	462.0	484.0	238.0	40.0	215.0	90.0
5	140.0	80.0	297.0	90.0	464.0	77.0	430.0	342.0	453.0	284.0	135.0	80.0
6	162.0	236.0	208.0	352.0	357.0	363.0	633.0	325.0	361.0	270.0	218.0	56.0
7	194.0	106.0	296.0	336.0	611.0	211.0	548.0	201.0	406.0	344.0	34.0	38.0
8	132.0	174.0	386.0	234.0	618.0	642.0	196.0	300.0	464.0	102.0	36.0	76.0
9	160.0	150.0	154.0	170.0	387.0	694.0	535.0	434.0	442.0	242.0	206.0	24.0
10	82.0	253.0	116.0	180.0	628.0	404.0	474.0	222.0	18.0	292.0	144.0	104.0
11	110.0	302.0	220.0	187.0	618.0	152.0	163.0	460.0	32.0	266.0	52.0	124.0
12	110.0	291.0	154.0	308.0	604.0	266.0	176.0	455.0	142.0	150.0	128.0	130.0
13	188.0	214.0	48.0	504.0	520.0	318.0	565.0	508.0	280.0	122.0	144.0	148.0
14	134.0	169.0	136.0	494.0	122.0	536.0	569.0	236.0	412.0	78.0	200.0	96.0
15	134.0	256.0	80.0	78.0	518.0	262.0	618.0	350.0	177.0	146.0	54.0	54.0
16	150.0	170.0	126.0	72.0	138.0	377.0	238.0	449.0	336.0	98.0	52.0	106.0
17	126.0	136.0	282.0	516.0	530.0	682.0	416.0	512.0	369.0	80.0	133.0	44.0
18	38.0	136.0	230.0	562.0	190.0	692.0	568.0	546.0	130.0	307.0	57.0	30.0
19	24.0	158.0	104.0	464.0	104.0	126.0	499.0	512.0	262.0	280.0	202.0	30.0
20	56.0	110.0	444.0	144.0	86.0	586.0	532.0	447.0	46.0	277.0	24.0	81.0
21	80.0	304.0	444.0	122.0	142.0	689.0	634.0	358.0	178.0	218.0	185.0	180.0
22	46.0	294.0	418.0	224.0	238.0	490.0	584.0	497.0	129.0	196.0	168.0	####
23	152.0	192.0	405.0	568.0	212.0	674.0	547.0	134.0	127.0	84.0	116.0	####
24	132.0	290.0	448.0	576.0	426.0	361.0	615.0	530.0	366.0	250.0	30.0	####
25	26.0	383.0	356.0	538.0	630.0	639.0	302.0	314.0	116.0	106.0	164.0	####
26	147.0	226.0	228.0	486.0	566.0	503.0	421.0	254.0	132.0	37.0	6.0	####
27	150.0	390.0	88.0	570.0	220.0	272.0	478.0	369.0	96.0	42.0	160.0	####
28	190.0	270.0	412.0	558.0	620.0	584.0	326.0	375.0	192.0	228.0	42.0	####
29	186.0		396.0	129.0	644.0	638.0	352.0	474.0	121.0	68.0	72.0	####
30	232.0		430.0	150.0	632.0	538.0	575.0	484.0	44.0	186.0	150.0	####
31	244.0		468.0		546.0		440.0	446.0		244.0		####
SUM	3891.0	5611.0	8489.0	10242.0	13406.0	14288.0	14583.0	12405.0	7368.0	5496.0	3561.0	######

Daily Average Air Temperature (C)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1985/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-0.7	-11.0	1.2	-1.6	9.8	14.1	17.4	16.3	14.5	8.8	8.0	-1.1
2	-4.4	-13.7	-3.0	-2.1	10.0	16.3	17.8	16.5	17.6	6.1	6.7	-0.3
3	-6.1	-15.6	-6.6	0.1	9.6	11.9	18.3	17.6	20.1	7.5	8.0	-1.6
4	-5.3	-14.9	-5.2	2.7	9.9	12.2	19.6	18.6	21.7	10.1	7.1	-3.0
5	-4.5	-10.2	-5.5	8.8	14.5	14.5	19.5	18.9	21.6	7.4	6.1	-2.6
6	-1.1	-9.6	-8.6	1.3	11.8	13.3	17.3	19.5	21.7	5.7	4.0	-2.0
7	-3.4	-12.8	-2.0	1.0	9.7	14.8	14.3	20.1	22.9	7.8	4.3	-3.0
8	-12.4	-11.8	2.5	-3.1	6.5	18.5	19.1	20.4	21.1	12.0	2.5	-2.5
9	-12.9	-9.3	-0.9	-5.7	11.7	19.4	19.6	20.9	19.6	12.8	2.3	-1.1
10	-10.5	-7.5	1.6	-0.4	19.0	14.3	17.5	20.0	14.1	9.7	-0.1	-0.3
11	-8.4	-3.3	3.3	4.1	18.6	9.3	15.5	15.6	9.8	5.8	-3.0	-1.6
12	-1.2	-0.1	0.5	3.2	19.6	9.5	16.5	15.2	7.8	5.7	3.1	-3.0
13	-12.2	-2.0	-1.1	3.8	16.6	8.7	19.6	20.0	8.5	12.8	5.1	-6.5
14	-4.8	-8.1	0.1	10.5	15.6	11.9	22.7	20.6	10.6	10.2	1.5	-11.4
15	-12.3	-9.7	-4.6	13.7	12.6	13.6	19.8	17.7	11.2	9.9	-0.4	-9.0
16	-10.3	-9.7	-0.4	7.7	13.9	14.4	15.6	17.4	11.6	4.9	-0.6	-8.7
17	-6.6	-3.6	-7.4	1.3	10.4	14.7	16.6	18.2	13.9	5.3	1.8	-13.2
18	-6.2	-3.9	-8.1	13.1	6.7	13.8	18.1	19.6	16.2	12.3	4.9	-14.5
19	-9.9	-7.2	-0.5	13.9	11.5	12.6	19.7	15.1	19.9	12.4	13.3	-12.3
20	-18.5	-5.4	-1.4	12.7	14.5	14.0	20.0	13.8	19.0	8.4	1.7	-11.0
21	-16.5	-1.1	-3.8	17.5	9.0	17.3	17.7	14.6	14.2	9.1	1.5	-10.7
22	-5.1	2.9	-0.4	20.4	10.4	18.3	14.5	15.0	16.3	8.8	-0.4	-7.4
23	-6.3	4.1	0.7	19.9	14.5	19.0	14.2	15.7	18.8	2.3	5.2	-2.6
24	-4.6	3.4	-0.8	15.1	16.6	14.1	17.6	16.0	11.7	12.4	5.8	-8.3
25	-6.3	-0.1	-3.5	12.3	17.6	14.3	22.6	18.6	10.2	8.4	1.7	-15.4
26	-11.7	0.3	-0.5	10.2	14.8	14.2	18.8	17.2	12.1	9.1	-3.0	-15.0
27	-8.1	-7.6	7.1	6.6	14.7	16.3	17.4	17.3	10.3	8.8	-2.6	-8.5
28	-6.4	-5.4	7.3	6.7	12.7	17.7	18.4	17.7	11.6	2.3	-2.6	-13.1
29	-7.7		3.6	10.0	11.6	17.4	20.9	16.6	13.2	1.7	-3.0	-9.3
30	-7.5		-0.2	14.0	14.7	16.8	17.6	16.0	14.5	3.4	-2.5	-8.2
31	-5.9		-1.2		17.9		14.9	13.6		5.3		-2.6
AVER	-7.7	-6.2	-1.2	7.3	13.1	14.6	18.0	17.4	15.2	8.0	2.6	-6.8

Daily Average Air Temperature (C)

ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	-9.1	-6.7	-8.4	11.2	11.4	23.6	15.1	19.4	15.3	12.5	9.1	-4.7
2	-4.8	-3.4	-1.6	4.7	2.6	183.4	16.5	16.4	16.2	12.6	2.8	-1.4
3	-3.9	-3.2	1.0	5.4	4.0	12.5	12.9	15.7	16.0	15.0	3.3	-1.0
4	-7.5	-2.2	0.0	4.8	9.9	18.5	15.7	16.8	18.6	10.8	2.0	-4.3
5	-7.6	-1.5	-0.1	2.6	18.0	15.6	22.1	17.8	15.6	8.0	2.6	-4.5
6	-10.6	-8.7	-3.8	8.8	19.1	14.8	23.9	19.1	11.2	5.0	4.5	-3.3
7	-13.2	-8.0	-15.4	8.8	14.6	18.6	22.6	17.7	7.8	7.3	5.2	-2.7
8	-13.1	-8.0	-13.8	3.5	13.1	19.3	19.2	17.7	10.4	11.5	9.5	-6.6
9	-6.1	-6.1	-2.8	-0.2	11.2	15.6	17.8	17.6	12.8	4.7	3.2	-3.1
10	-3.6	-12.8	4.6	-2.0	14.1	19.1	16.8	17.3	15.3	2.6	-2.7	-7.0
11	-3.0	-12.8	-2.2	-1.4	15.1	20.2	13.9	13.4	18.1	7.5	-1.7	-7.1
12	-0.7	-12.9	-2.7	-0.8	14.1	18.8	14.8	14.2	12.3	12.4	-3.8	-6.6
13	-13.2	-13.6	0.0	3.4	15.4	16.2	18.7	15.7	10.1	11.7	-9.4	-12.4
14	-15.2	-9.0	1.6	7.6	14.6	15.8	16.3	17.5	8.0	6.7	-7.6	-5.1
15	-14.7	-10.4	0.5	6.3	17.2	16.5	17.7	21.2	6.1	3.8	-1.4	-1.5
16	-4.8	-8.7	-0.6	4.9	18.1	17.5	17.6	20.4	6.8	4.3	-0.9	-1.4
17	2.6	-3.6	-1.0	10.9	18.5	9.8	20.6	20.9	7.9	4.6	1.2	-0.4
18	2.3	-0.3	0.8	10.9	18.3	13.1	24.4	20.0	12.6	4.2	-2.4	-0.8
19	1.4	0.5	2.3	13.4	12.4	14.7	22.9	17.5	14.5	6.0	-7.0	-2.2
20	-2.4	-0.4	-13.2	9.8	10.7	16.2	21.0	18.9	13.8	8.6	-4.5	-2.5
21	-3.2	-7.3	-9.1	4.1	9.5	16.9	16.3	19.4	12.6	11.0	-3.5	-4.2
22	-2.0	-10.1	-0.9	-1.8	12.0	21.0	17.8	16.0	15.3	12.1	-1.4	###
23	-7.4	-6.5	2.5	2.7	12.2	19.2	20.7	16.3	16.6	11.0	1.0	###
24	-7.3	-6.9	-2.1	8.1	14.3	11.2	20.9	13.3	15.9	5.2	-0.3	###
25	-2.4	-10.9	7.5	13.6	16.7	11.7	21.3	13.2	14.6	5.2	-0.4	###
26	-5.8	-10.8	9.1	15.6	19.2	16.5	20.5	17.5	18.7	7.5	1.4	###
27	-15.2	-12.0	-0.4	17.9	16.6	19.1	20.4	11.2	12.1	9.7	1.5	###
28	-16.5	-9.1	4.1	19.3	18.9	20.9	19.6	7.1	15.8	9.4	-1.2	###
29	-11.8		12.6	10.4	22.4	17.1	17.7	10.1	19.0	9.3	-0.1	###
30	-10.1		12.7	11.1	23.2	13.9	19.2	13.2	17.1	3.5	-4.5	###
31	-10.1		6.8		21.9		18.6	14.0		6.0		###
AVER	-7.1	-7.3	-0.4	7.1	14.8	22.2	18.8	16.3	13.6	8.1	-0.2	####

APPENDIX F

SOILS AND SEDIMENT DATA

TABLE F1 ATRAZINE SOIL MOISTURE/TEMP. DATA 84-86

		Depth	P1		P2		P3		N3		TB-3	
			Moist.[1]	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C
1984: Nov.	12	.3	8.8	-	9.4	-			9.5	-	9.1	-
		1	9.3		9.6				9.5		9.5	
	17	.3	9.5	-	9.4	-			9.6	-	9.0	-
		1	9.4		9.5				9.6		8.8	
	30	.3	7.8	-	9.7	-			9.5		8.9	-
		1	9.3		9.8				9.4		8.8	
Dec.	12	.3	9.3	-	9.5	-			9.4	-	9.3	-
		1	9.3		9.5				9.3		9.2	
	21	.3	7.8	-	9.4	-			9.4	-	9.5	-
		1	9.0		9.6				9.6		9.5	
1985: Apr.	22	.3	9.8	-	9.5	-			9.6	-	9.4	-
		1	9.5		9.6				9.8		9.5	
May	2	.3	9.5	-	9.7	-			9.5	-	9.5	-
		1	9.8		9.8				9.8		9.4	
	16	.3	9.3	-	6.5	-			9.0	-	9.6	-
		1	9.8		9.5				9.5		5.3	
	22	.3	9.4	-	4.5	-			7.8	-	8.8	-
		1	9.8		9.6				9.7		3.5	
	28	.3	9.7	-	4.2	-			7.5	-	7.3	-
		1	9.8		9.7				9.5		2.9	

TABLE F1

ATRAZINE SOIL MOISTURE/TEMP. DATA 84-86

		Depth	P1		P2		P3		N3		TB-3	
			Moist.[1]	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C	Moist.	Temp. °C
June	1	.3	9.7	-	4.4	-			7.5	-	6.6	-
		1	9.7		9.6				9.5		2.5	
	6	.3	9.5	19.0	2.6	17.0			6.5	19.5	4.8	19.0
		1	10.0		9.7				9.5		1.5	
	24	.3	9.6	23.0	8.4	19.0			9.7	16.8	3.6	19.7
		1	9.7		9.4				9.7		9.2	
July	4	.3	9.7	21.0	5.3	17.5	installed	9.2	20.0	3.0	19.3	
		1	9.2		8.8				9.6		2.5	
	19	.3	9.2	23.5	9.2	20.0	9.5	20.8	9.8	-	2.5	21.2
		1	9.8		9.2		9.7		9.7		1.2	
Aug.	5	.3	4.0	-	3.7	-	4.5	-	6.6	-	0.9	-
		1	9.6		9.2		9.5		8.4		0.3	
	17	.3	6.2	17.8	1.8	21.1	3.6	17.8	8.4	15.6	0.2	16.7
		1	9.8		9.4		8.8		8.6		0.5	
Sept.	2	.3	9.5	25.6	9.4	21.7	9.5	20.0	9.8	16.1	0.8	17.8
		1	9.8		9.0		9.8		6.9		9.8	
	25	.3	9.5	15.0	8.0	15.5	8.5	14.4	8.8	11.0	2.3	12.2
		1	9.8		9.8		9.5		9.5		5.8	
Oct.	30	.3	9.3	8.6	9.0	7.7	9.5	5.5	9.3	5.5	9.3	5.0
		1	9.5		9.3		9.8		9.8		9.0	
Nov.	14	.3	9.5	4.4	9.2	5.0	9.8	5.0	9.3	5.0	9.4	4.4
		1	9.8		9.5		10.0		9.5		9.2	
Dec.	10	.3	9.3	0.5	9.0	2.2	9.0	1.1	9.3	1.0	9.5	1.1
		1	9.5		9.8		9.5		9.5		9.3	

TABLE F1 ATRAZINE SOIL MOISTURE/TEMP. DATA 84-86

1986 - SOIL MOISTURE/TEMP.

		Time	Depth	P1		P2		P3		N3		TB-3	
				Moist.[1] °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.
1986: March	10	14:30	1' 3'	9.25 9.00	1.1°C	-	-	-	-	-	-	-	-
March	24	13:30	1' 3'	8.75 9.50	-0.5	-	-	9.00 9.25	-1.1	8.75 9.00	0.0	9.50 9.00	-1.1
April	8	14:30	1' 3'	9.25 9.75	7.8	9.50 9.50	5.6	9.25 9.25	4.4	9.00 9.00	5.0	9.50 9.25	5.0
April	17	13:00	1' 3'	9.50 9.50	11.1	9.25 9.40	8.9	9.25 9.50	5.6	9.30 9.75	8.9	9.25 9.00	6.7
May	1	12:30	1' 3'	9.40 9.50	14.4	9.25 9.50	11.1	9.25 9.50	10.0	9.25 9.30	10.0	9.50 9.50	11.1
May	13	12:45	1' 3'	9.00 9.50	20.0	7.50 9.75	16.7	5.00 9.50	15.6	8.25 9.25	10.6	9.00 7.75	14.4
May	20	13:00	1' 3'	9.75 9.75	13.3	9.25 9.25	13.3	-	-	9.50 9.25	12.2	9.40 9.25	12.2
May	21	14:30	1' 3'	9.75 9.50	11.7	9.30 9.50	11.7	9.50 9.75	11.1	9.50 9.50	11.1	9.50 9.50	12.2
June	5	13:15	1' 3'	9.25 9.75	16.1	6.00 9.75	15.6	4.50 9.80	15.6	7.00 9.70	14.4	9.50 5.25	14.4
June	24	13:00	1' 3'	9.50 9.75	20.0	6.75 9.20	17.8	8.00 9.75	15.6	9.75 9.75	15.6	7.25 2.50	15.6
Aug.	7	14:00	1' 3'	-	-	-	-	-	-	9.25 9.75	18.3	3.00 1.00	18.5

TABLE F1: ATRAZINE SOIL MOISTURE/TEMP. DATA 84-86

1986 - SOIL MOISTURE/TEMP.

		Time	Depth	P1		P2		P3		N3		TB-3	
				Moist.[1] °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.	Moist. °C	Temp.
Aug.	11	16:00	1'	9.60	21.7	9.50	19.4	9.50	17.8	-	-	-	-
			3'	9.75		9.50		9.50					
Sept.	3	13:00	1'	9.50	16.6	6.50	15.6	5.60	15.6	8.75	12.2	3.25	14.4
			3'	9.70		8.50		9.50		9.50		2.50	
Sept.	18	12:30	1'	9.50	10.6	9.50	11.1	9.25	13.9	9.50	10.6	8.50	11.1
			3'	9.50		9.75		9.75		9.50		9.50	
Oct.	10	14:30	1'	9.25	8.3	9.75	7.2	9.00	6.7	9.25	6.1	9.50	6.1
			3'	9.50		9.75		9.75		9.75		9.50	
Dec.	18	12:00	1'	-	-	9.25	1.11	9.00	0.5	9.25	0.0	9.30	0.5
			3'			9.75		9.25		9.50		9.00	

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[1] moisture units are relative units on a Delmhorst soil moisture system scale of 0 to 10.0.

SOIL MOISTURE MEASUREMENT METHODS

The Delmhorst soil moisture measuring system was used in this study as an indicator of the time varying nature of soil moisture levels in the unsaturated zone of the soil matrix. Gypsum blocks were buried at depths of 0.3 and 1.0 metres at the locations indicated in Figure 4.18. These blocks absorb or release moisture as a function of available soil moisture. Relative soil moisture is therefore measured by electrical conductivity (a function of moisture) within the gypsum block. Each soil has a different capacity to hold moisture depending on its texture and structure.

Meter readings can be converted to total potential reserve, (i.e., remaining water which is available) or suction required to draw the moisture from the soil. The device is designed to guide farmers in determining the best time to irrigate.

The attached figures were taken from the instrument manual and provide a conversion from meter reading to moisture tension and percentage of water used.

Soil specific studies are required on each soil type in order to convert these values to absolute soil moisture values. This was not done in this study since that level of detail was not necessary.

Figure 1

KS-1 METER READINGS VERSUS BARS TENSION AND RESISTANCE

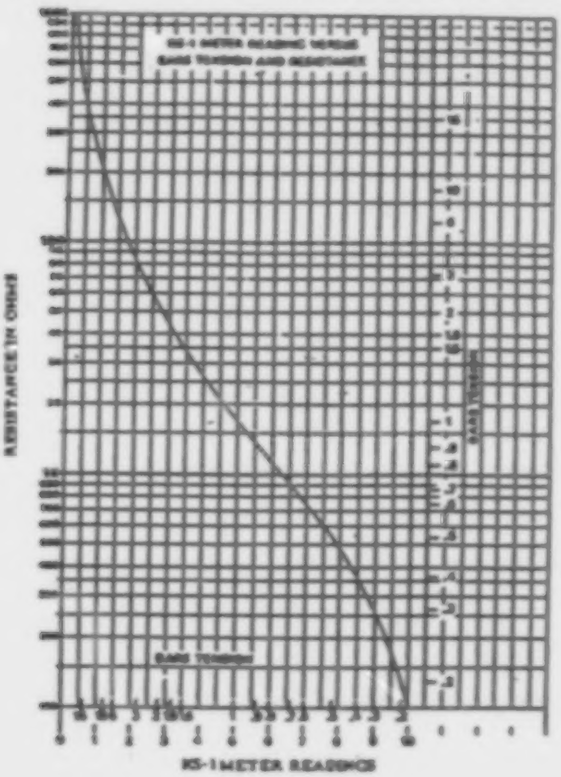
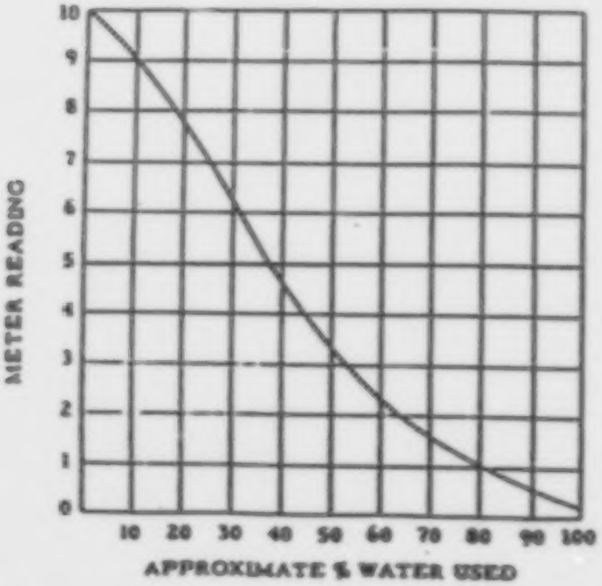


FIGURE #2

KS-1 Meter Readings versus approx. % water used



APPENDIX G

BEST MANAGEMENT PRACTICE DEFINITIONS

WORKING DEFINITIONS OF CANDIDATE BMPs

Nonstructural measures

1. No-tillage - A method of planting crops that involves no seedbed preparation other than opening the soil for the purpose of placing the seed at the intended depth. This usually involves opening a small slit or punching a hole into the soil. There is usually no cultivation during crop production. Chemical weed control is normally used. Also referred to as slot planting or zero tillage. Soil surface is generally protected by crop residues or sod.

2. Conservation tillage - Any tillage system which reduces loss of soil and water compared to unridged clean tillage. Reduction of soil and water loss is accomplished in most cases by reducing the extent of tillage and by protecting the surface with crop residues. Measures which may be considered conservation tillage include:

    a) till-planting - No preplant tillage is performed. Tillage is performed at time of planting with a till-planter. With this system, wide sweep and trash bars clear a strip over the old row, and a narrow planter shoe opens a seed furrow into which seed is dropped. A narrow wheel presses the seed into firm soil; covering disks place loose soil over the seed.

    b) chisel plowing - This system breaks or loosens the soil without inversion. Chisel plows are generally operated at depths equal to or slightly deeper than moldboard plows, usually 8 to 10 inches. When used in dry soils, chiseling loosens the soil and leaves up to two thirds of the residue at or very near the surface.

    c) disking - accomplished by an implement called a disk harrow, disking can be used to perform primary or secondary tillage. Disk blades vary in size up to 30 inches in diameter, and each pass of a disk incorporates at least 30% to 70% of the plant residues. Disking permits incorporation of surface-applied nutrients and herbicides.

3. Contour farming - Conducting field operations, such as plowing, planting, cultivating, and harvesting on the natural field contour. Due to its ineffectiveness on long

or steep slopes, contouring is often combined with strip cropping or terracing. Used in areas of 2-8% slope.

4. Graded rows - Where poor drainage or the likelihood of severe storms are a problem, rows on a slight gradient may be used rather than contouring to prevent breaking over of rows.

5. Contour strip cropping - The practice of growing crops in comparatively narrow strips of land on which the farming operations are performed on the contour. Strips of grass, close growing crops, or fallow are alternated with cultivated crops. Contour strip cropping implies both contouring and crop rotation.

6. Spring plowing - Delayed tillage from fall to spring can reduce soil erosion losses. Soil porosity at planting time is enhanced by spring tillage, and exposure of disturbed soil to wind, thaw runoff, and early spring rains is minimized.

7. Sod-based rotation - The inclusion of broadcast grass or legumes in the temporal crop rotation for an agricultural field. A typical rotation has been a few years of row crops, followed by one year of small grain, followed by at least three years of a sod crop such as alfalfa, followed again by row crops. Runoff and sediment loss is substantially reduced during the sod years.

8. Winter cover crop - A close growing crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production. A typical situation is a cover crop following corn silage on soybean harvest, if the crop leaves insufficient residue to protect the soil against erosion.

9. Permanent meadow - Topography or soil conditions may result in situations where other management practices are ineffective or too costly. In such cases conversion to permanent meadow may be the only solution.

10. Mechanical cultivation - Use of mechanical weeding devices. This practice reduces the need for herbicides, but results in disruption of land surface and dislodging of soil. This alternative represents an increase in cultivation from conventional practices.

11. Crop rotation - The growing of different crops in recurring succession on the same land. Rotations offer advantages for erosion, pesticide, and nutrient control. Deep rooted crops and crops with low nitrogen needs should be included in the rotation.

Structural measures

1. Terraces - Embankments or combinations of embankments and channels contructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Excess water is removed slowly from the field through nearly-level terrace channels to grassed outlets or is removed through a subsurface drain. Eroded soil within the terrace interval accumulates in the terrace channel where more than 80% of it remains.

2. Diversions - Channels with ridges on their lower sides, constructed across the slope, for the purpose of diverting water from areas where it is in excess to sites where it can be used or disposed of safely.

3. Grassed waterways - Natural or constructed waterways, usually broad and shallow covered with erosion-resistant grasses, used to conduct surface water from cropland.

4. Filter strips - Strips of permanent vegetation above farm ponds, diversion terraces, and other structures to retard flow of runoff water, resulting in deposition of transported material.

5. Tile drainage - Removal of excess surface water or groundwater from land by means of surface or subsurface drains.

6. Retention basins - Localized depressions which serve as storage and settling areas for storm runoff.

Input Management Options

1. Improve soil fertility - Improving soil fertility increases crop yields and reduces soil erosion. Reduction in erosion is attributed to improved crop canopy, increased water use efficiency by plants, and the availability of more residue for soil protection.

2. Eliminate excess applications of nutrients or pesticides - Fertilizer and pesticide inputs into crop production should not exceed that needed for plant nutrient uptake and pest control. Fertilizer rates should be based on crop nutrient budgets which account for green legumes and manurial sources of plant nutrients.

3. Optimize timing of planting and chemical application - The least loss of nutrients from a field occurs when fertilizer

is applied as close to time of utilization by the crop as possible. Likewise, careful timing of pesticide application reduces the possibility of pesticide runoff. Thus the relative times of planting and chemical application can influence the uptake, effectiveness, and runoff of the applied chemicals. However, in Iowa a relatively narrow range exists for economic row-crop planting times.

4. Controlling release and chemical transformations - Methods of controlling the rate of release of nitrogen include (a) nitrification inhibitors, (b) coatings to retard the hydrolysis of urea to NH4-N and (c) inhibition of urease activity in soil. Selection of chemicals with favorable half-life and adsorption properties is included in this option.

5. Biological control - Included in biological management measures are: (a) use of pest resistant strains of crop and (b) utilization of natural enemies of a pest for control (predators, disease).

6. Incorporation of applied chemicals - Fertilizers or pesticides are applied to the land surface, and tillage is performed to incorporate the chemicals into the soil. In some cases, incorporation is performed by the application equipment.

APPENDIX H

HSPF UTILITY MODULES

```
b                 b
b                 b
b                 b
b bbb     oooo    b bbb
bb   b   o    o   bb   b
b     b  o    o   b     b
b     b  o    o   b     b
bb   b   o    o   bb   b
b bbb     oooo    b bbb
```

```
DDDDD     IIIII    SSSSS   PPPPPP   L          AAA    Y     Y  DDDDD    EEEEEEE  M     M    OOO
 D   D      I     S     S  P     P  L         A   A   Y     Y   D   D   E        MM   MM   O   O
 D    D     I     S        P     P  L        A     A   Y   Y    D    D  E        M M M M  O     O
 D    D     I     S        P     P  L        A     A    Y Y     D    D  E        M  M  M  O     O
 D    D     I      SSSSS   PPPPPP   L        AAAAAAA     Y      D    D  EEEEEE   M     M  O     O
 D    D     I           S  P        L        A     A     Y      D    D  E        M     M  O     O
 D    D     I           S  P        L        A     A     Y      D    D  E        M     M  O     O
 D   D      I     S     S  P        L        A     A     Y      D   D   E        M     M   O   O
DDDDD     IIIII    SSSSS   P        LLLLLLL  A     A     Y     DDDDD    EEEEEEE  M     M    OOO
```

```
BBBBBB                     k
 B    B                    k
 B    B                    k
 B    B   eeee      aaaa   k   k
 BBBBB   e    e         a  k  k
 B    B  eeeeee     aaaaa  k k
 B    B  e         a     a kk k
 B    B  e    e    a    aa k   k
BBBBBB    eeee      aaaa a k    k
```

```
Job:  DISPLAYDEMO
Date: Wed Jun  3 10:31:53 1987
```

```
RUN
GLOBAL
  DISPLAY OBSERVED AND PREDICTED PESTICIDE LOADS 1986
  <--8X--><--START-DATE/TIME-> *** <---END-DATE/TIME-->
  START       1986/01/01  0:00  END    1986/12/21 24:00
  RUN INTERP OUTPUT LEVEL .   3...
  RESUME     0 RUN     1 TSSFL     15
END GLOBAL
OPN SEQUENCE
    <--------19X--------> ***  <IDT>
    INGRP                INDELT 24:00
***   <OPTYP AND ##>
      DISPLY        1
    END INGRP
    INGRP                INDELT  1:00
***   <OPTYP AND ##>
      DISPLY        2
    END INGRP
END OPN SEQUENCE
*** display operation - this block specifies that a short span display will
*** be made (pivl=1) and written to file 51.
DISPLY
  DISPLY-INFO1
    # -  ****<-----------title------------>  tran <-short-span->  <annual summary-->
***                                          tran pivl dig1 fil1  pyr dig2 fil2 yrnd
    1       Obs. Daily Pest Load N1 (kg)  SUM     1    3   51    1    3   51   12
    2       Pred Daily Pest Load N1 (kg)  SUM     1    3   51    1    3   51   12
  END DISPLY-INFO1
  DISPLY-INFO2
    # -  #  Set Threshold Value                       ***
***                                   THRSH1          ***
    1    2                              -1.0
  END DISPLY-INFO2
END DISPLY
*** external sources - this block directs the data from the a TSS data set
*** to be an input time series for the display operations
EXT SOURCES
<-volume-> <member> SsysSgap<--mult-->Tran <-target vols> <-grp> <-member->  ***
<name>   # <name> # tem strg<-factor->strg <name>   #   #        <name> # #  ***
TSS    161 OATRN1   METR                   DISPLY   1     INPUT  TIMSER
TSS    121 SATRN1   METR                   DISPLY   2     INPUT  TIMSER
END EXT SOURCES
END RUN
```

```
1
                                        Obs. Daily Pest Load N1 (kg)

                                        SUMMARY FOR MONTH  1986/ 1/

                                        DATA INTERVAL:  1440 MINS

      DAY        SUM                    INTERVAL NUMBER
                               1

        1       0.000       0.000
        2       0.000       0.000
        3       0.000       0.000
        4       0.000       0.000
        5       0.000       0.000

        6       0.000       0.000
        7       0.000       0.000
        8       0.000       0.000
        9       0.000       0.000
       10       0.000       0.000

       11       0.000       0.000
       12       0.000       0.000
       13       0.000       0.000
       14       0.000       0.000
       15       0.000       0.000

       16       0.000       0.000
       17       0.000       0.000
       18       0.000       0.000
       19       0.000       0.000
       20       0.000       0.000

       21       0.000       0.000
       22       0.000       0.000
       23       0.000       0.000
       24       0.000       0.000
       25       0.000       0.000

       26       0.000       0.000
       27       0.000       0.000
       28       0.000       0.000
       29       0.000       0.000
       30       0.000       0.000

       31       0.000       0.000
  MONTH  SUM : 0.00000e+00
1
                                        Obs. Daily Pest Load N1 (kg)

                                        SUMMARY FOR MONTH  1986/ 2/

                                        DATA INTERVAL:  1440 MINS

      DAY        SUM                    INTERVAL NUMBER
                               1

        1       0.000       0.000
        2       0.000       0.000
        3       0.000       0.000
        4       0.000       0.000
        5       0.000       0.000
       6         0.000          0.000
       7         0.000          0.000
       8         0.000          0.000
       9         0.000          0.000
      10         0.000          0.000

      11         0.000          0.000
      12         0.014          0.014
      13         0.000          0.000
      14         0.000          0.000
      15         0.000          0.000

      16         0.000          0.000
      17         0.000          0.000
      18         0.000          0.000
      19         0.000          0.000
      20         0.000          0.000

      21         0.000          0.000
      22         0.000          0.000
      23         0.000          0.000
      24         0.011          0.011
      25         0.000          0.000

      26         0.000          0.000
      27         0.000          0.000
      28         0.000          0.000
  MONTH  SUM : 2.50000e-02
 1
                                               Obs. Daily Pest Load N1 (kg)

                                               SUMMARY FOR MONTH  1986/ 3/

                                               DATA INTERVAL:  1440 MINS

     DAY         SUM                           INTERVAL NUMBER
                                    1


       1         0.000          0.000
       2         0.000          0.000
       3         0.000          0.000
       4         0.010          0.010
       5         0.000          0.000

       6         0.000          0.000
       7         0.000          0.000
       8         0.000          0.000
       9         0.000          0.000
      10         0.085          0.085

      11         0.291          0.291
      12         0.120          0.120
      13         0.086          0.086
      14         0.000          0.000
      15         0.000          0.000

      16         0.000          0.000
      17         0.000          0.000
      18         0.175          0.175
      19         0.585          0.585
      20         0.200          0.200

      21         0.082          0.082
      22         0.000          0.000
      23         0.000          0.000
      25        0.000        0.000

      26        0.000        0.000
      27        0.000        0.000
      28        0.000        0.000
      29        0.000        0.000
      30        0.000        0.000

      31        0.000        0.000
  MONTH  SUM : 1.63350e+00
 1
                                              Obs. Daily Pest Load N1 (kg)

                                              SUMMARY FOR MONTH  1986/ 4/

                                              DATA INTERVAL:  1440 MINS

     DAY        SUM                           INTERVAL NUMBER
                                  1

       1        0.000        0.000
       2        0.000        0.000
       3        0.000        0.000
       4        0.000        0.000
       5        0.000        0.000

       6        0.000        0.000
       7        0.000        0.000
       8        0.012        0.012
       9        0.000        0.000
      10        0.000        0.000

      11        0.000        0.000
      12        0.000        0.000
      13        0.000        0.000
      14        0.000        0.000
      15        0.000        0.000

      16        0.000        0.000
      17        0.000        0.000
      18        0.000        0.000
      19        0.000        0.000
      20        0.042        0.042

      21        0.190        0.190
      22        0.110        0.110
      23        0.000        0.000
      24        0.000        0.000
      25        0.000        0.000

      26        0.000        0.000
      27        0.000        0.000
      28        0.000        0.000
      29        0.000        0.000
      30        0.000        0.000

  MONTH  SUM : 3.54100e-01
 1
                                              Obs. Daily Pest Load N1 (kg)

                                              SUMMARY FOR MONTH  1986/ 5/

                                              DATA INTERVAL:  1440 MINS

     DAY        SUM                           INTERVAL NUMBER
                                  1
      1        0.010          0.010
      2        0.000          0.000
      3        0.000          0.000
      4        0.000          0.000
      5        0.000          0.000

      6        0.000          0.000
      7        0.000          0.000
      8        0.000          0.000
      9        0.000          0.000
     10        0.000          0.000

     11        0.000          0.000
     12        0.000          0.000
     13        0.004          0.004
     14        0.000          0.000
     15        0.000          0.000

     16        0.000          0.000
     17        0.000          0.000
     18        0.000          0.000
     19        0.000          0.000
     20        0.194          0.194

     21        0.191          0.191
     22        0.050          0.050
     23        0.000          0.000
     24        0.000          0.000
     25        0.000          0.000

     26        0.019          0.019
     27        0.000          0.000
     28        0.000          0.000
     29        0.000          0.000
     30        0.000          0.000

     31        0.000          0.000
 MONTH  SUM : 4.68000e-01
1
                                           Obs. Daily Pest Load N1 (kg)

                                           SUMMARY FOR MONTH  1986/ 6/

                                           DATA INTERVAL:  1440 MINS

    DAY        SUM                         INTERVAL NUMBER
                                  1

      1        0.000          0.000
      2        0.000          0.000
      3        0.000          0.000
      4        0.000          0.000
      5        0.006          0.006

      6        0.000          0.000
      7        0.000          0.000
      8        0.000          0.000
      9        0.000          0.000
     10        0.000          0.000

     11        0.025          0.025
     12        0.236          0.236
     13        0.089          0.089
     14        0.000          0.000
     15        0.000          0.000
     16        0.000        0.000
     17        0.000        0.000
     18        0.000        0.000
     19        0.000        0.000
     20        0.000        0.000

     21        0.000        0.000
     22        0.000        0.000
     23        0.000        0.000
     24        0.023        0.023
     25        0.000        0.000

     26        0.000        0.000
     27        0.000        0.000
     28        0.000        0.000
     29        0.000        0.000
     30        0.000        0.000

  MONTH  SUM : 3.76800e-01
 1
                                          Obs. Daily Pest Load N1 (kg)

                                          SUMMARY FOR MONTH  1966/ 7/

                                          DATA INTERVAL:  1440 MINS

    DAY        SUM                        INTERVAL NUMBER
                                1

      1        0.000        0.000
      2        0.000        0.000
      3        0.000        0.000
      4        0.000        0.000
      5        0.000        0.000

      6        0.000        0.000
      7        0.000        0.000
      8        0.000        0.000
      9        0.006        0.006
     10        0.000        0.000

     11        0.005        0.005
     12        0.018        0.018
     13        0.015        0.015
     14        0.000        0.000
     15        0.000        0.000

     16        0.050        0.050
     17        0.037        0.037
     18        0.036        0.036
     19        0.311        0.311
     20        0.102        0.102

     21        0.062        0.062
     22        0.038        0.038
     23        0.000        0.000
     24        0.000        0.000
     25        0.000        0.000

     26        0.000        0.000
     27        0.000        0.000
     28        0.000        0.000
     29        0.000        0.000
     30        0.000        0.000
```

```
   31        0.000          0.000
MONTH  SUM : 6.79400e-01
1
                                        Obs. Daily Pest Load N1 (kg)

                                        SUMMARY FOR MONTH  1986/ 8/

                                        DATA INTERVAL:  1440 MINS

     DAY         SUM                    INTERVAL NUMBER
                                1

      1        0.000          0.000
      2        0.000          0.000
      3        0.000          0.000
      4        0.000          0.000
      5        0.000          0.000

      6        0.000          0.000
      7        0.080          0.080
      8        0.132          0.132
      9        0.136          0.136
     10        0.066          0.066

     11        0.052          0.052
     12        0.000          0.000
     13        0.000          0.000
     14        0.000          0.000
     15        0.000          0.000

     16        0.000          0.000
     17        0.000          0.000
     18        0.000          0.000
     19        0.000          0.000
     20        0.000          0.000

     21        0.000          0.000
     22        0.000          0.000
     23        0.000          0.000
     24        0.000          0.000
     25        0.000          0.000

     26        0.000          0.000
     27        0.000          0.000
     28        0.000          0.000
     29        0.000          0.000
     30        0.000          0.000

     31        0.000          0.000
MONTH  SUM : 4.67800e-01
1
                                        Obs. Daily Pest Load N1 (kg)

                                        SUMMARY FOR MONTH  1986/ 9/

                                        DATA INTERVAL:  1440 MINS

     DAY         SUM                    INTERVAL NUMBER
                                1

      1        0.000          0.000
      2        0.000          0.000
      3        0.002          0.002
      4        0.000          0.000
      5        0.000          0.000
      6         0.000          0.000
      7         0.000          0.000
      8         0.000          0.000
      9         0.000          0.000
     10         0.050          0.050

     11         0.180          0.180
     12         0.707          0.207
     13         0.107          0.107
     14         0.050          0.050
     15         0.061          0.061

     16         0.096          0.096
     17         0.061          0.061
     18         0.033          0.033
     19         0.000          0.000
     20         0.000          0.000

     21         0.000          0.000
     22         0.000          0.000
     23         0.000          0.000
     24         0.000          0.000
     25         0.000          0.000

     26         0.000          0.000
     27         0.000          0.000
     28         0.000          0.000
     29         0.000          0.000
     30         0.000          0.000

 MONTH  SUM : 8.46500e-01
1
                                            Obs. Daily Pest Load N1 (kg)

                                            SUMMARY FOR MONTH  1956/10/

                                            DATA INTERVAL:  1440 MINS

    DAY         SUM                         INTERVAL NUMBER
                                1

      1         0.000          0.000
      2         0.000          0.000
      3         0.171          0.171
      4         0.363          0.383
      5         0.347          0.347

      6         0.000          0.000
      7         0.000          0.000
      8         0.000          0.000
      9         0.000          0.000
     10         0.000          0.000

     11         0.000          0.000
     12         0.024          0.024
     13         0.121          0.121
     14         0.187          0.187
     15         0.112          0.112

     16         0.079          0.079
     17         0.000          0.000
     18         0.000          0.000
     19         0.000          0.000
     20         0.000          0.000

     21         0.000          0.000
     22         0.000          0.000
```

```
   22       0.000        0.000
   23       0.000        0.000
   24       0.000        0.000
   25       0.000        0.000

   26       0.000        0.000
   27       0.000        0.000
   28       0.000        0.000
   29       0.000        0.000
   30       0.000        0.000

   31       0.000        0.000
MONTH  SUM : 1.42360e+00
1
                                          Obs. Daily Pest Load N1 (kg)

                                          SUMMARY FOR MONTH  1986/11/

                                          DATA INTERVAL:  1440 MINS

  DAY       SUM                           INTERVAL NUMBER
                             1

    1       0.000        0.000
    2       0.000        0.000
    3       0.000        0.000
    4       0.000        0.000
    5       0.012        0.012

    6       0.000        0.000
    7       0.000        0.000
    8       0.000        0.000
    9       0.000        0.000
   10       0.000        0.000

   11       0.000        0.000
   12       0.000        0.000
   13       0.000        0.000
   14       0.000        0.000
   15       0.000        0.000

   16       0.000        0.000
   17       0.000        0.000
   18       0.010        0.010
   19       0.000        0.000
   20       0.000        0.000

   21       0.000        0.000
   22       0.000        0.000
   23       0.000        0.000
   24       0.000        0.000
   25       0.000        0.000

   26       0.000        0.000
   27       0.000        0.000
   28       0.000        0.000
   29       0.000        0.000
   30       0.000        0.000

MONTH  SUM : 2.20000e-02
1
                                          Obs. Daily Pest Load N1 (kg)

                                          SUMMARY FOR MONTH  1986/12/
```

```
DAY          SUM                          INTERVAL NUMBER
                              1

  1         0.000        0.000
  2         0.000        0.000
  3         0.000        0.000
  4         0.000        0.000
  5         0.000        0.000

  6         0.000        0.000
  7         0.000        0.000
  8         0.000        0.000
  9         0.000        0.000
 10         0.000        0.000

 11         0.000        0.000
 12         0.000        0.000
 13         0.000        0.000
 14         0.000        0.000
 15         0.000        0.000

 16         0.000        0.000
 17         0.000        0.000
 18         0.000        0.000
 19         0.000        0.000
 20         0.000        0.000

 21         0.000        0.000
 22         0.000        0.000
 23         0.000        0.000
 24         0.000        0.000
 25         0.000        0.000

 26         0.000        0.000
 27         0.000        0.000
 28         0.000        0.000
 29         0.000        0.000
 30         0.000        0.000

 31         0.000        0.000
MONTH SUM : 0.00000e+00
1


                         Obs. Daily Pest Load N1 (kg)

              ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

DAY      JAN    FEB    MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

  1     0.000  0.000  0.000  0.000  0.010  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  2     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  3     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.002  0.171  0.000  0.000
  4     0.000  0.000  0.010  0.000  0.000  0.000  0.000  0.000  0.000  0.383  0.010  0.000
  5     0.000  0.000  0.000  0.000  0.000  0.006  0.000  0.000  0.000  0.347  0.012  0.000

  6     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  7     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.090  0.000  0.000  0.000  0.000
  8     0.000  0.000  0.000  0.012  0.000  0.000  0.000  0.137  0.000  0.000  0.000  0.000
  9     0.000  0.000  0.006  0.000  0.000  0.000  0.006  0.138  0.000  0.000  0.000  0.000
 10     0.000  0.000  0.085  0.000  0.000  0.000  0.000  0.066  0.050  0.000  0.000  0.000
```

```
     12       0.000    0.014    0.120    0.000    0.000    0.258    0.010    0.000    0.237    0.024    0.000    0.000
     13       0.000    0.000    0.086    0.000    0.004    0.089    0.015    0.000    0.107    0.121    0.000    0.000
     14       0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.250    0.187    0.000    0.000
     15       0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.061    0.112    0.000    0.000

     16       0.000    0.000    0.000    0.000    0.000    0.000    0.050    0.000    0.096    0.079    0.000    0.000
     17       0.000    0.000    0.000    0.000    0.000    0.000    0.037    0.000    0.061    0.000    0.000    0.000
     18       0.000    0.000    0.175    0.000    0.000    0.000    0.036    0.000    0.033    0.000    0.010    0.000
     19       0.000    0.000    0.585    0.000    0.000    0.000    0.311    0.000    0.000    0.000    0.000    0.000
     20       0.000    0.000    0.200    0.042    0.194    0.000    0.102    0.000    0.000    0.000    0.000    0.000

     21       0.000    0.000    0.082    0.190    0.191    0.000    0.062    0.000    0.000    0.000    0.000    0.000
     22       0.000    0.000    0.000    0.110    0.050    0.000    0.038    0.000    0.000    0.000    0.000    0.000
     23       0.000    0.000    0.005    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     24       0.000    0.011    0.000    0.000    0.000    0.023    0.000    0.000    0.000    0.000    0.000    0.000
     25       0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000

     26       0.000    0.000    0.000    0.000    0.019    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     27       0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     28       0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     29       0.000             0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     30       0.000             0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000    0.000
     31       0.000             0.000             0.000             0.000    0.000             0.000             0.000
0 SUM         0.000    0.025    1.634    0.354    0.468    0.379    0.679    0.468    0.846    1.424    0.022    0.000

  SUM  OF MONTHLY VALUES  6.29870e+00
1
                                   Pred Daily Pest Load N1 (kg)

                                   SUMMARY FOR MONTH  1986/ 11

                                   DATA INTERVAL:     60 MINS

    DAY          SUM                     INTERVAL NUMBER
                                 1        2        3        4        5        6        7        8        9       10       11       12
                                13       14       15       16       17       18       19       20       21       22       23       24


     1          0.020          0.000    0.000    0.000    0.000    0.000    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     2          0.030          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     3          0.031          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     4          0.031          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     5          0.030          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001

     6          0.029          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     7          0.029          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     8          0.028          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
     9          0.027          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
    10          0.028          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001

    11          0.028          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
    12          0.035          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.002    0.002    0.003    0.002    0.002    0.002    0.001    0.001    0.001    0.001    0.001
    13          0.031          0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
                               0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001    0.001
```

```
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   15          0.026            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

   16          0.024            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   17          0.043            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.002   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003
   18          0.053            0.003   0.003   0.003   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                                0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
   19          0.139            0.002   0.029   0.029   0.011   0.006   0.005   0.004   0.004   0.004   0.003   0.003   0.003
                                0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003
   20          0.059            0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002   0.003
                                0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002

   21          0.048            0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                                0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
   22          0.042            0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                                0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
   23          0.038            0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                                0.002   0.002   0.002   0.002   0.002   0.002   0.001   0.002   0.002   0.002   0.001   0.001
   24          0.035            0.002   0.002   0.001   0.001   0.001   0.001   0.002   0.002   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   25          0.033            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

   26          0.033            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   27          0.031            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   28          0.028            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   29          0.026            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   30          0.026            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

   31          0.026            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 MONTH  SUM : 1.11505e+00
1
                                       Pred Daily Pest Load N1 (kg)

                                       SUMMARY FOR MONTH  1986/ 2/

                                       DATA INTERVAL:     60 MINS

  DAY          SUM                     INTERVAL NUMBER
                                    1       2       3       4       5       6       7       8       9      10      11      12
                                   13      14      15      16      17      18      19      20      21      22      23      24


    1          0.025            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    2          0.024            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    3          0.027            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    4          0.026            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    5          0.029            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                0.001   0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002   0.001   0.001   0.001
  7        0.027        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  8        0.026        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  9        0.025        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 10        0.025        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

 11        0.023        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 12        0.023        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 13        0.022        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 14        0.021        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 15        0.019        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

 16        0.018        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 17        0.017        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 18        0.025        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002   0.002   0.002
 19        0.085        0.002   0.001   0.001   0.001   0.001   0.001   0.007   0.013   0.006   0.003   0.003   0.003
                        0.003   0.003   0.003   0.003   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004
 20        0.069        0.004   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003
                        0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002   0.002

 21        0.054        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                        0.002   0.002   0.002   0.002   0.002   0.003   0.003   0.003   0.003   0.003   0.003   0.002
 22        0.049        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
 23        0.037        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                        0.002   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 24        0.032        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 25        0.031        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

 26        0.028        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 27        0.025        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 28        0.023        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
MONTH  SUM : 8.58415e-01
1
                                  Pred Daily Pest Load N1 (kg)

                                  SUMMARY FOR MONTH  1986/ 3/

                                  DATA INTERVAL:    60 MINS

  DAY       SUM                   INTERVAL NUMBER
                           1       2       3       4       5       6       7       8       9      10      11      12
                          13      14      15      16      17      18      19      20      21      22      23      24

  1        0.031        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                        0.001   0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002   0.002   0.002   0.002
  2        0.049        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
```

```
                          0.002  0.002  0.003  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003
  4        0.072          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
  5        0.083          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.004  0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004  0.004

  6        0.086          0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003
                          0.003  0.003  0.003  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004
  7        0.085          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.003  0.003  0.004  0.005  0.005  0.005  0.004  0.004  0.004  0.004
  8        0.095          0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003
                          0.003  0.003  0.003  0.004  0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004
  9        0.087          0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003
                          0.003  0.003  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003
 10        0.186          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.004  0.004  0.007  0.006  0.007  0.007  0.016  0.056  0.027  0.013

 11        0.153          0.010  0.007  0.007  0.007  0.007  0.007  0.007  0.007  0.007  0.007  0.006  0.006
                          0.006  0.006  0.006  0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005
 12        0.096          0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004
                          0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003
 13        0.065          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 14        0.051          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 15        0.044          0.002  0.002  0.002  0.002  0.002  0.002  0.002  [illegible]  0.002  0.002  0.002  0.002
                          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002

 16        0.037          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                          0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 17        0.034          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001
 18        0.031          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 19        0.124          0.001  0.003  0.013  0.018  0.012  0.007  0.004  0.004  0.004  0.004  0.004  0.005
                          0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004
 20        0.070          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                          0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002

 21        0.048          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 22        0.037          0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                          0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 23        0.030          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 24        0.026          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 25        0.023          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

 26        0.022          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 27        0.029          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 28        0.023          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 29        0.020          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 30        0.018          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

 31        0.017          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                          0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
MONTH  SUM :  1.84182e+00
```

```
                                     SUMMARY FOR MONTH  1986/ 4/

                                     DATA INTERVAL:     60 MINS

DAY          SUM                     INTERVAL NUMBER
                            1       2       3       4       5       6       7       8       9      10      11      12
                           13      14      15      16      17      18      19      20      21      22      23      24


  1         0.016         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  2         0.016         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  3         0.014         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  4         0.014         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  5         0.021         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

  6         0.024         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  7         0.019         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  8         0.015         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
  9         0.014         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 10         0.012         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000   0.000

 11         0.011         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 12         0.011         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 13         0.010         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 14         0.010         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 15         0.016         0.000   0.000   0.000   0.000   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

 16         0.027         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 17         0.023         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 18         0.017         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 19         0.014         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 20         0.049         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.000   0.001   0.001   0.002   0.006   0.006   0.006   0.006   0.006   0.007

 21         0.198         0.008   0.008   0.009   0.011   0.011   0.010   0.009   0.009   0.008   0.008   0.007   0.007
                          0.007   0.007   0.008   0.008   0.009   0.009   0.009   0.008   0.007   0.007   0.007   0.006
 22         0.102         0.006   0.006   0.005   0.005   0.005   0.005   0.005   0.005   0.005   0.004   0.004   0.004
                          0.004   0.004   0.004   0.004   0.004   0.004   0.003   0.003   0.003   0.003   0.003   0.003
 23         0.058         0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002
                          0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
 24         0.037         0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                          0.002   0.002   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
 25         0.026         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
```

```
014          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
012          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000
011          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

465364-01

                         Pred Daily Pest Load N1 (kg)

                         SUMMARY FOR MONTH  1986/ 5/

                         DATA INTERVAL:    60 MINS

UM                       INTERVAL NUMBER
                 1       2       3       4       5       6       7       8       9      10      11      12
                13      14      15      16      17      18      19      20      21      22      23      24


014          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
012          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000   0.000   0.000   0.000
010          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
009          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
008          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

025          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002   0.003   0.003   0.003
067          0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003
             0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002   0.002   0.002
042          0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
             0.002   0.002   0.002   0.002   0.002   0.002   0.001   0.001   0.001   0.001   0.001   0.001
025          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
015          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

011          0.001   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
008          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
007          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
006          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
004          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
             0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

071          0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.002   0.002   0.002   0.002
036          0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
             0.002   0.002   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
032          0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
             0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.002   0.003   0.003   0.004
278          0.004   0.004   0.005   0.005   0.006   0.008   0.009   0.011   0.011   0.012   0.015   0.016
             0.017   0.017   0.016   0.016   0.015   0.015   0.014   0.013   0.013   0.012   0.012   0.011
463          0.011   0.011   0.010   0.010   0.009   0.009   0.009   0.009   0.008   0.010   0.015   0.021
             0.021   0.022   0.024   0.029   0.033   0.034   0.032   0.031   0.029   0.027   0.026   0.025
```

```
    21        0.379        0.023   0.022   0.021   0.021   0.020   0.019   0.018   0.018   0.017   0.016   0.016   0.015
                           0.015   0.014   0.014   0.014   0.013   0.013   0.012   0.012   0.012   0.011   0.011   0.011
    22        0.184        0.010   0.010   0.010   0.010   0.009   0.009   0.009   0.009   0.008   0.008   0.008   0.008
                           0.007   0.007   0.007   0.007   0.007   0.006   0.006   0.006   0.006   0.006   0.006   0.006
    23        0.111        0.005   0.005   0.005   0.005   0.006   0.006   0.006   0.005   0.005   0.005   0.005   0.005
                           0.005   0.005   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.003   0.003
    24        0.058        0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002
                           0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
    25        0.035        0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

    26        0.022        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    27        0.015        0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
    28        0.011        0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    29        0.009        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    30        0.007        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

    31        0.006        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
 MONTH  SUM : 1.93081e+00
1
                                        Pred Daily Pest Load N1 (kg)

                                        SUMMARY FOR MONTH  1986/ 6/

                                        DATA INTERVAL:    60 MINS

   DAY        SUM                       INTERVAL NUMBER
                               1       2       3       4       5       6       7       8       9      10      11      12
                              13      14      15      16      17      18      19      20      21      22      23      24


     1        0.006        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     2        0.005        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     3        0.005        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     4        0.005        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     5        0.004        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

     6        0.004        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     7        0.004        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     8        0.004        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     9        0.003        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    10        0.003        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

    11        0.007        0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.001   0.001   0.001
    12        1.442        0.001   0.002   0.008   0.072   0.130   0.148   0.128   0.110   0.096   0.086   0.075   0.067
 14      0.267        0.015  0.015  0.014  0.014  0.014  0.013  0.013  0.012  0.012  0.012  0.011  0.011
                      0.011  0.011  0.010  0.010  0.010  0.009  0.009  0.009  0.009  0.008  0.008  0.008
 15      0.148        0.008  0.008  0.008  0.007  0.007  0.007  0.007  0.007  0.007  0.006  0.006  0.006
                      0.006  0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005

 16      0.111        0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003
                      0.003  0.003  0.003  0.003  0.003  0.004  0.005  0.006  0.007  0.008  0.009  0.008
 17      0.150        0.008  0.008  0.008  0.008  0.008  0.007  0.007  0.007  0.007  0.007  0.006  0.006
                      0.006  0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.004
 18      0.081        0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003
                      0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
 19      0.045        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.001  0.001  0.001
 20      0.024        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

 21      0.016        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 22      0.012        0.001  0.001  0.001  0.001  0.000  0.000  0.000  [illegible]  [illegible]  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001  0.001  0.001  0.001  0.001
 23      0.038        0.001  0.001  0.001  0.001  0.001  0.001  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 24      0.047        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 25      0.037        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

 26      0.021        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 27      0.085        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.002
                      0.002  0.003  0.004  0.006  0.007  0.007  0.008  0.008  0.008  0.008  0.008  0.008
 28      0.134        0.007  0.007  0.007  0.007  0.007  0.007  0.006  0.006  0.006  0.006  0.006  0.006
                      0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004
 29      0.073        0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003  0.003  0.003
                      0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002  0.002
 30      0.040        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

MONTH SUM : 3.39461e+00
1
                                   Pred Daily Pest Load N2 (kg)

                                   SUMMARY FOR MONTH  1996/ 7/

                                   DATA INTERVAL:    60 MINS

DAY      SUM                       INTERVAL NUMBER
                        1      2      3      4      5      6      7      8      9     10     11     12
                       13     14     15     16     17     18     19     20     21     22     23     24

  1      0.023        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  2      0.014        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  3      0.009        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  4      0.006        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  5      0.005        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  6      0.004        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
   9       0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  10       0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  11       0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  12       0.033      0.000  0.000  0.000  0.001  0.001  0.001  0.001  0.001  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.001  0.001
  13       0.026      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  14       0.016      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  15       0.012      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.000  0.000
                      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  16       0.088      0.000  0.000  0.000  0.000  0.001  0.002  0.003  0.003  0.004  0.004  0.005  0.005
                      0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005
  17       0.078      0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003
                      0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002
  18       0.088      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.003  0.013  0.036
  19       0.481      0.045  0.042  0.038  0.035  0.031  0.028  0.025  0.023  0.021  0.019  0.017  0.016
                      0.015  0.014  0.014  0.013  0.012  0.012  0.011  0.011  0.011  0.010  0.010  0.009
  20       0.235      0.009  0.010  0.011  0.013  0.013  0.014  0.014  0.013  0.012  0.012  0.011  0.010
                      0.010  0.009  0.009  0.008  0.008  0.008  0.007  0.007  0.007  0.007  0.006  0.006

  21       0.104      0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.004  0.004
                      0.004  0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003  0.003  0.003
  22       0.056      0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
  23       0.037      0.002  0.002  0.002  0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  24       0.019      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  25       0.012      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.000  0.000  0.000
                      0.000  0.000  0.000  0.001  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001

  26       0.931      0.016  0.065  0.152  0.126  0.080  0.064  0.053  0.044  0.038  0.033  0.030  0.027
                      0.025  0.023  0.022  0.020  0.019  0.018  0.018  0.017  0.016  0.016  0.015  0.014
  27       0.236      0.014  0.013  0.013  0.013  0.012  0.012  0.011  0.011  0.011  0.010  0.010  0.010
                      0.009  0.009  0.009  0.009  0.008  0.008  0.008  0.008  0.007  0.007  0.007  0.007
  28       0.126      0.007  0.006  0.006  0.006  0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005
                      0.005  0.005  0.004  0.004  0.004  0.004  0.005  0.005  0.004  0.004  0.004  0.004
  29       0.099      0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004
                      0.004  0.004  0.004  0.004  0.004  0.003  0.003  0.003  0.003  0.003  0.003  0.003
  30       0.053      0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002  0.002  0.002
                      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002

  31       0.030      0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
MONTH  SUM : 2.82519e+00
1
                                 Pred Daily Pest Load N1 (kg)

                                 SUMMARY FOR MONTH  1996/ 8/

                                 DATA INTERVAL:    60 MINS

  DAY          SUM               INTERVAL NUMBER
                        1      2      3      4      5      6      7      8      9     10     11     12
                       13     14     15     16     17     18     19     20     21     22     23     24
```

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2	0.012	0.001	0.001	0.001	0.001	0.001	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	[illegible]	[illegible]	0.001	0.001	0.001	0.001	0.001
3	0.014	0.001	0.001	0.001	0.001	0.001	0.001	[illegible]	0.001	0.001	0.001	0.001	0.001
		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
4	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.006
8	0.246	0.006	0.006	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
		0.004	0.004	0.004	0.007	0.011	0.013	0.019	0.024	0.026	0.025	0.023	0.021
9	0.307	0.020	0.019	0.018	0.017	0.016	0.016	0.015	0.014	0.014	0.013	0.013	0.012
		0.012	0.012	0.011	0.011	0.010	0.010	0.010	0.009	0.009	0.009	0.009	0.008
10	0.141	0.008	0.008	0.008	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.006
		0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004
11	0.072	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
		0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002
12	0.040	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
13	0.024	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
14	0.015	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
15	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
MONTH  SUM : 1.02059e+00
:
                                      Pred Daily Pest Load NI (kg)

                                      SUMMARY FOR MONTH  1986/ 9/

                                      DATA INTERVAL:    60 MINS

  DAY          SUM                    INTERVAL NUMBER
                               1       2       3       4       5       6       7       8       9      10      11      12
                              13      14      15      16      17      18      19      20      21      22      23      24

    1        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    2        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    3        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    4        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    5        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

    6        0.002         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    7        0.001         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    8        0.001         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
    9        0.001         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
   10        0.175         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.001   0.008   0.018   0.026   0.022   0.019   0.017   0.015   0.014   0.013   0.012   0.012

   11        0.244         0.013   0.013   0.013   0.012   0.013   0.013   0.012   0.011   0.011   0.010   0.010   0.010
                           0.009   0.009   0.010   0.010   0.009   0.009   0.009   0.009   0.008   0.008   0.008   0.008
   12        0.196         0.007   0.007   0.009   0.013   0.012   0.011   0.010   0.010   0.009   0.009   0.009   0.008
                           0.008   0.008   0.008   0.007   0.007   0.007   0.007   0.007   0.006   0.006   0.006   0.006
   13        0.103         0.006   0.006   0.005   0.005   0.005   0.005   0.005   0.005   0.005   0.004   0.004   0.004
                           0.004   0.004   0.004   0.004   0.004   0.004   0.004   0.003   0.003   0.003   0.003   0.003
   14        0.058         0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002
                           0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
   15        0.040         0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
                           0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002

   16        0.029         0.002   0.002   0.002   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   17        0.019         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   18        0.013         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000
   19        0.009         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
   20        0.009         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000  -0.000   0.000   0.000

   21        0.007         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                           0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
   22        0.012         0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001
                           0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
   23        0.015         0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
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 25        0.007        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

 26        0.006        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
 27        0.006        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
 28        0.005        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
 29        0.035        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001  0.001  0.001  0.001
                        0.002  0.004  [illegible]  0.002  0.002  0.003  0.003  0.003  0.003  0.003  0.003  0.003
 30        0.238        0.006  0.011  0.018  0.019  0.013  0.010  0.009  0.008  0.008  0.007  0.007  0.007
                        0.007  0.007  0.009  0.008  0.008  0.007  0.007  0.007  0.007  0.006  0.006  0.006

MONTH  SUM : 1.22006e+00
:

                              Pred Daily Pest Load N1 (kg)

                              SUMMARY FOR MONTH  1986/10/

                              DATA INTERVAL:    60 MINS

DAY        SUM                INTERVAL NUMBER
                          1      2      3      4      5      6      7      8      9     10     11     12
                         13     14     15     16     17     18     19     20     21     22     23     24

  1        0.119        0.006  0.006  0.006  0.006  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005
                        0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004  0.004  0.004  0.005  0.005
  2        0.090        0.005  0.005  0.005  0.005  0.005  0.004  0.004  0.004  0.004  0.004  0.004  0.004
                        0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
  3        0.066        0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002
                        0.002  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
  4        0.056        0.003  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                        0.002  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002  0.002  0.002  0.002
  5        0.041        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                        0.002  0.002  0.002  0.002  0.002  0.002  0.001  0.001  0.001  0.002  0.002  0.002

  6        0.051        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
                        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
 .7        0.036        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.001
                        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  8        0.031        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.002
                        0.002  0.002  0.002  0.002  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  9        0.022        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
 10        0.016        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

 11        0.013        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.000  0.000  0.000
 12        0.011        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001
 13        0.078        0.001  0.001  0.002  0.003  0.004  0.005  0.005  0.005  0.004  0.004  0.004  0.004
                        0.004  0.004  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
 14        0.197        0.003  0.003  0.008  0.016  0.016  0.014  0.012  0.011  0.010  0.009  0.009  0.008
                        0.008  0.007  0.007  0.007  0.007  0.006  0.006  0.006  0.006  0.006  0.006  0.006
 15        0.106        0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.005  0.004
                        0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004  0.004

 16        0.068        0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                        0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.002  0.002  0.002  0.002  0.002
 17        0.045        0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
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                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
      19          0.022            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
      20          0.016            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

      21          0.013            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      22          0.010            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      23          0.008            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      24          0.007            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      25          0.006            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

      26          0.005            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      27          0.031            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.001   0.001   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003
      28          0.056            0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.003   0.002   0.002   0.002   0.002
                                   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002
      29          0.033            0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.002   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
      30          0.021            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001

      31          0.014            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.000   0.000
 MONTH  SUM : 1.32121e+00
1
                                              Pred Daily Pest Load Ni (kg)

                                              SUMMARY FOR MONTH  1986/11/

                                              DATA INTERVAL:    60 MINS

     DAY          SUM                         INTERVAL NUMBER
                                     1       2       3       4       5       6       7       8       9      10      11      12
                                    13      14      15      16      17      18      19      20      21      22      23      24

       1          0.011            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001
       2          0.019            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
                                   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001
       3          0.012            0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.001   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
       4          0.010            0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
       5          0.007            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

       6          0.005            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
       7          0.004            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
       8          0.006            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
       9          0.005            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      10          0.004            0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
                                   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

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  12      0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  13      0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  14      0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  15      0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  16      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  17      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  18      0.003      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  19      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  20      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  21      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  22      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  23      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  24      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
  25      0.002      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

  26      0.081      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001  0.001  0.001  0.001
                     0.002  0.002  0.002  0.002  0.003  0.006  0.014  0.013  0.011  0.009  0.007  0.006
  27      0.065      0.005  0.004  0.004  0.004  0.003  0.003  0.003  0.003  0.003  0.003  0.003  0.003
                     0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
  28      0.033      0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.001  0.001  0.001  0.001
                     0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  29      0.020      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                     0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
  30      0.013      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                     0.001  0.001  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

MONTH  SUM : 3.31728e-01
1
                                 Pred Daily Pest Load N1 (kg)

                                 SUMMARY FOR MONTH  1996/12/

                                 DATA INTERVAL:     60 MINS

  DAY     SUM                    INTERVAL NUMBER
                        1      2      3      4      5      6      7      8      9     10     11     12
                       13     14     15     16     17     18     19     20     21     22     23     24


   1      0.000      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
   2      0.021      0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                     0.000  0.001  0.001  0.001  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
   3      0.027      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                     0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
   4      0.018      0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                     0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
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      6       0.006        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
      7       0.005        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
      8       0.004        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
      9       0.003        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     10       0.005        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

     11       0.007        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     12       0.007        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     13       0.007        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     14       0.007        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     15       0.008        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

     16       0.010        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.001  0.001  0.001  0.000  0.000
     17       0.012        0.001  0.001  0.001  0.000  0.000  0.001  0.001  0.001  0.000  0.000  0.001  0.001
                           0.000  0.000  0.000  0.001  0.001  0.000  0.000  0.000  0.001  0.001  0.000  0.000
     18       0.039        0.000  0.000  0.001  0.001  0.001  0.001  0.002  0.002  0.002  0.002  0.002  0.002
                           0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002  0.002
     19       0.034        0.002  0.002  0.002  0.002  0.002  0.001  0.002  0.002  0.001  0.001  0.001  0.001
                           0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
     20       0.024        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                           0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001

     21       0.019        0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
                           0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001  0.001
     22       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     23       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     24       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     25       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

     26       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     27       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     28       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     29       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
     30       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000

     31       0.000        0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
                           0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
 MONTH  SUM : 2.79815e-01
1
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                 ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING [illegible]

 DAY      JAN     FEB     MAR     APR     MAY     JUN     JUL     AUG     SEP     OCT     NOV     DEC

   1    0.020   0.025   0.031   0.016   0.014   0.006   0.023   0.018   0.002   0.119   0.011   0.008
   2    0.030   0.024   0.049   0.016   0.012   0.005   0.014   0.012   0.002   0.093   0.019   0.021
   3    0.031   0.027   0.068   0.014   0.010   0.005   0.009   0.014   0.002   0.066   0.012   0.027
   4    0.031   0.026   0.072   0.014   0.009   0.005   0.006   0.010   0.002   0.055   0.010   0.018
   5    0.030   0.029   0.083   0.021   0.008   0.004   0.005   0.006   0.002   0.041   0.007   0.010

   6    0.029   0.028   0.088   0.024   0.025   0.004   0.004   0.005   0.002   0.051   0.005   0.006
   7    0.029   0.027   0.086   0.019   0.067   0.004   0.003   0.035   0.001   0.036   0.004   0.005
   8    0.028   0.026   0.095   0.015   0.042   0.004   0.003   0.246   0.001   0.031   0.006   0.004
   9    0.027   0.025   0.087   0.014   0.025   0.003   0.003   0.307   0.001   0.022   0.005   0.003
  10    0.028   0.025   0.186   0.012   0.015   0.003   0.002   0.141   0.175   0.016   0.004   0.005

  11    0.028   0.023   0.153   0.011   0.011   0.007   0.002   0.072   0.244   0.013   0.004   0.007
  12    0.035 [illegible] 0.096 0.011   0.008   1.462   0.033   0.040   0.196   0.011   0.003   0.007
  13    0.031   0.022   0.065   0.010   0.007   0.550   0.026   0.024   0.103   0.078   0.003   0.007
  14    0.030   0.021   0.051   0.010   0.006   0.269   0.016   0.015   0.058   0.197   0.003   0.007
  15    0.026   0.019   0.044   0.016   0.006   0.148   0.012   0.010   0.040   0.106   0.003   0.008

  16    0.024   0.016   0.037   0.027   0.021   0.111   0.088   0.007   0.029   0.068   0.002   0.010
  17    0.043   0.017   0.034   0.023   0.036   0.150   0.078   0.005   0.019   0.045   0.002   0.012
  18    0.053   0.025   0.031   0.017   0.032   0.081   0.088   0.004   0.013   0.031   0.003   0.039
  19    0.139   0.085   0.124   0.014   0.278   0.045   0.481   0.004   0.009   0.022   0.002   0.034
  20    0.059   0.069   0.070   0.049   0.463   0.026   0.235   0.003   0.009   0.016   0.002   0.024

  21    0.048   0.054   0.048   0.198   0.379   0.016   0.104   0.003   0.007   0.013   0.002   0.019
  22    0.042   0.049   0.037   0.102   0.184   0.012   0.056   0.003   0.012   0.010   0.002   0.000
  23    0.038   0.037   0.030   0.058   0.111   0.038   0.032   0.004   0.015   0.008   0.002   0.000
  24    0.035   0.032   0.026   0.037   0.058   0.047   0.019   0.007   0.010   0.007   0.002   0.000
  25    0.033   0.030   0.023   0.026   0.035   0.037   0.012   0.005   0.007   0.006   0.002   0.000

  26    0.033   0.028   0.022   0.020   0.022   0.021   0.931   0.004   0.006   0.005   0.081   0.000
  27    0.031   0.025   0.029   0.016   0.015   0.085   0.236   0.007   0.006   0.031   0.065   0.000
  28    0.028   0.023   0.023   0.014   0.011   0.134   0.126   0.005   0.005   0.056   0.033   0.000
  29    0.026           0.020   0.012   0.009   0.073   0.099   0.003   0.035   0.033   0.020   0.000
  30    0.026           0.018   0.011   0.007   0.040   0.053   0.003   0.208   0.021   0.013   0.000
  31    0.026           0.017           0.006           0.030   0.002           0.014           0.000
0 SUM   1.115   0.858   1.842   0.847   1.931   3.395   2.825   1.021   1.220   1.321   0.332   0.280

 SUM  OF MONTHLY VALUES  1.69858e+01
```

```
b                  b
b                  b
b                  b
b bbb     oooo     b bbb
bb   b   o    o    bb   b
b     b  o    o    b     b
b     b  o    o    b     b
bb   b   o    o    bb   b
b bbb     oooo     b bbb


  GGGG    EEEEEEE   N     N   EEEEEEE   RRRRRR    DDDDD     EEEEEEE   M     M     OOO
 G    G   E         NN    N   E         R     R    D   D    E         MM   MM    O   O
G         E         N N   N   E         R     R    D    D   E         M M M M   O     O
G         E         N  N  N   E         R     R    D    D   E         M  M  M   O     O
G         EEEEEE    N   N N   EEEEEE    RRRRRR     D    D   EEEEEE    M     M   O     O
G  GGGG   E         N    NN   E         R  R       D    D   E         M     M   O     O
G     G   E         N     N   E         R   R      D    D   E         M     M   O     O
 G    G   E         N     N   E         R    R     D   D    E         M     M    O   O
  GGGG    EEEEEEE   N     N   EEEEEEE   R     R   DDDDD     EEEEEEE   M     M     OOO


BBBBBB                        k
 B    B                       k
 B    B                       k
 B    B    eeee      aaaa     k   k
 BBBBB    e    e         a    k  k
 B    B   eeeeee    aaaaa     k k
 B    B   e         a    a    kk k
 B    B   e    e    a   aa    k   k
BBBBBB     eeee      aaaa a   k    k


                                        Job:  GENERDEMO
                                        Date: Wed Jun  3 14:27:51 1987
```

```
RUN
*** This GENER UCI Performs a Multiplication of Hourly Streamflow by Hourly
*** Predicted Pesticide Concentrations to Determine Loads in Grams. The Hourly
*** Predicted Loads are Aggragated into Six Hour Intervals. Results are
*** Displayed.
GLOBAL
  CONDUCT A GENER TRANSFORMATION ON THE 1986 TSS
  <--8X--><--START-DATE/TIME-> *** <---END-DATE/TIME-->
  START       1986/01/01  0:00  END    1986/12/21 24:00
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1 TSSFL    15
END GLOBAL
*** operation sequence - this block specifies that an hourly timestep
*** is used and one transformation will be performed.
OPN SEQUENCE
    <-------19X-------> ***  <IDT>
    INGRP              INDELT  1:00
      <OPTYP AND ##> ***
      GENER        1
      DISPLY       1
    END INGRP
END OPN SEQUENCE
GENER
*** Operation Code Multiplies Two Time Series Together
  OPCODE
    #    #  OP-                                                          ***
          CODE                                                           ***
    1       18
  END OPCODE
END GENER
DISPLY
  DISPLY-INFO1
    #    ####<-----------Title--------->          <-short-span->
         ***                                      <--display---> <annual summary-->
         ***                                 TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1      6 HR Pest. Loads(GM), STN N1     SUM    6    2   51    1    2   51   12
  END DISPLY-INFO1
END DISPLY
*** external sources - this block directs the data from the TSS data set
*** to be an input time series for the GENER operations.  The subscript
*** after 'MEAN ' indicates the order in which the time series will be
*** used within the GENER file.
EXT SOURCES
<-volume-> <member> SsysSgap<--mult-->Tran <-target vols> <-grp> <-member->  ***
<name>   # <name> # tem strg<-factor->strg <name>   #   #        <name> # #  ***
TSS    101 SFLWN1   METR     1000000.      GENER    1      INPUT  ONE
TSS    301 OUTPT1   METR       .001        GENER    1      INPUT  TWO
END EXT SOURCES
NETWORK
<-Volume-> <Grp-> <-Member-><-Mfact--><Tr> <Target Vols-> <Tgrp> <Member-->***
<Name>    #        <Name> # #              <Name>   #   #         <Name> # ****
GENER    1 OUTPUT TIMSER                   DISPLY   1      INPUT  TIMSER
END NETWORK
END RUN
```

```
1
                                              6 HR Fest. Loads(GM), STN N1

                                              SUMMARY FOR MONTH  1986/ 1/

                                              DATA INTERVAL:   360 MINS

     DAY          SUM                          INTERVAL NUMBER
                                      1        2        3        4

       1         21.04              2.26     5.10     6.55     7.14
       2         30.00              7.35     7.45     7.56     7.64
       3         30.85              7.68     7.67     7.69     7.81
       4         30.72              7.76     7.71     7.65     7.60
       5         29.76              7.47     7.45     7.41     7.42

       6         29.40              7.43     7.40     7.32     7.26
       7         28.44              7.21     7.15     7.07     7.01
       8         27.54              6.97     6.91     6.85     6.82
       9         27.19              6.77     6.77     6.79     6.86
      10         27.89              6.89     6.93     7.01     7.07

      11         28.37              7.08     7.07     7.07     7.14
      12         35.22              7.22     7.29    12.31     8.41
      13         31.18              7.81     7.83     7.80     7.73
      14         29.70              7.63     7.49     7.32     7.26
      15         26.17              6.96     6.62     6.36     6.19

      16         24.06              6.09     6.02     5.99     5.96
      17         43.93              5.94     5.96    14.94    17.09
      18         52.80             14.87    13.63    12.60    11.69
      19        155.56             98.21    20.98    18.99    17.38
      20         58.69             15.92    15.11    14.25    13.47

      21         47.67             12.70    12.13    11.64    11.19
      22         41.69             10.81    10.51    10.28    10.08
      23         37.54              9.79     9.49     9.20     9.05
      24         34.48              8.82     8.69     8.57     8.41
      25         32.96              8.27     8.16     8.22     8.29

      26         32.65              8.26     8.19     8.10     8.10
      27         31.07              8.07     7.86     7.72     7.40
      28         27.53              7.24     7.03     6.74     6.52
      29         26.02              6.56     6.48     6.46     6.52
      30         25.91              6.50     6.49     6.43     6.48

      31         25.93              6.52     6.47     6.41     6.53
 MONTH  SUM : 1.13195e+03

                                              6 HR Fest. Loads(GM), STN N1

                                              SUMMARY FOR MONTH  1986/ 2/

                                              DATA INTERVAL:   360 MINS

     DAY          SUM                          INTERVAL NUMBER
                                      1        2        3        4

       1         25.19              6.55     6.50     6.44     5.70
       2         26.38              5.23     5.60     6.39     7.17
       3         26.73              6.69     6.60     6.67     6.76
       4         26.40              6.70     6.68     6.69     6.33
```

```
   6      [illegible]        [illegible]
   7      27.05        6.97    6.75    6.70    6.64
   8      25.43        6.48    6.32    6.30    6.33
   9      24.86        6.21    6.15    6.22    6.28
  10      24.59        6.27    6.12    6.12    6.09

  11      23.32        6.03    5.79    5.74    5.75
  12      22.54        5.80    5.58    5.52    5.64
  13      22.03        5.62    5.52    5.45    5.44
  14      21.29        5.28    5.27    5.33    5.41
  15      18.44        5.11    4.66    4.42    4.25

  16      15.90        4.09    3.97    3.87    3.97
  17      16.56        3.97    3.91    4.00    4.71
  18      25.76        4.71    4.54    6.98    9.53
  19      87.54       11.41   33.63   20.13   22.37
  20      68.73       20.03   17.82   16.12   14.77

  21      54.04       13.33   12.05   13.33   15.33
  22      48.11       13.72   12.40   11.41   10.57
  23      36.46        9.89    9.32    8.85    8.42
  24      31.59        8.01    7.66    7.73    8.19
  25      30.03        7.88    7.50    7.24    7.40

  26      27.57        7.27    6.98    6.75    6.58
  27      24.80        6.44    6.23    6.10    6.04
  28      23.36        5.97    5.85    5.78    5.75
MONTH  SUM : 6.60166e+02
:

                              6 HR Pest. Loads(GM), STN N1

                              SUMMARY FOR MONTH  1986/ 3/

                              DATA INTERVAL:   360 MINS

 DAY      SUM                 INTERVAL NUMBER
                         1       2       3       4

   1      30.99        5.72    5.68    7.83   11.75
   2      49.14       10.52    9.70   13.25   15.67
   3      68.33       14.08   12.86   20.78   20.61
   4      71.90       18.61   16.90   17.71   18.68
   5      83.74       16.86   15.50   26.22   25.16

   6      87.42       22.91   20.91   21.59   22.07
   7      85.68       19.78   17.70   22.33   25.87
   8      94.57       23.01   20.77   24.31   26.49
   9      86.75       23.60   21.28   21.43   20.44
  10     216.42       18.19   16.90   28.88  152.45

  11     150.30       44.84   39.60   34.95   30.91
  12      95.42       27.55   24.96   22.59   20.31
  13      64.41       18.35   16.66   15.26   14.14
  14      51.14       13.22   12.43   12.95   12.53
  15      43.41       11.69   11.03   10.53   10.16

  16      36.49        9.79    9.30    8.84    8.56
  17      33.56        6.34    7.97    8.72    8.54
  18      31.09        8.04    7.61    7.52    7.92
  19     129.58       59.43   24.38   23.76   22.01
  20      69.61       20.11   18.22   16.40   14.88

  21      48.12       13.56   12.43   11.47   10.66
  22      36.46        9.95    9.34    8.81    8.35
  23      [illegible]        [illegible]
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```
    25        22.34          [illegible] [illegible] [illegible] [illegible]

    26        22.33           5.32   5.20   5.24   6.56
    27        29.29           8.07   7.66   7.00   6.56
    28        23.33           6.23   5.94   5.69   5.47
    29        20.18           5.28   5.11   4.96   4.83
    30        18.17           4.70   4.59   4.49   4.39

    31        16.74           4.31   4.22   4.14   4.07
 MONTH  SUM : 1.87273e+03
1
                                        6 HR Pest. Loads(GM), STN N:

                                        SUMMARY FOR MONTH  1986/ 4/

                                        DATA INTERVAL:   360 MINS

   DAY        SUM                        INTERVAL NUMBER
                                1      2      3      4

    1         15.68           4.00   3.92   3.86   3.89
    2         15.68           4.08   3.98   3.86   3.76
    3         14.30           3.68   3.60   3.54   3.48
    4         13.52           3.44   3.41   3.36   3.31
    5         21.35           5.25   4.35   4.89   6.87

    6         24.15           6.79   6.26   5.75   5.34
    7         18.39           5.00   4.70   4.45   4.23
    8         15.30           4.05   3.89   3.74   3.62
    9         13.44           3.51   3.40   3.31   3.22
   10         12.25           3.15   3.08   3.04   2.98

   11         11.35           2.92   2.86   2.81   2.76
   12         10.65           2.71   2.67   2.64   2.63
   13         10.15           2.59   2.56   2.52   2.49
   14          9.64           2.46   2.42   2.39   2.36
   15         16.10           3.25   4.80   4.25   3.80

   16         27.07           4.59   6.85   8.30   7.33
   17         22.95           6.54   5.92   5.44   5.04
   18         17.08           4.69   4.38   4.12   3.90
   19         13.94           3.71   3.56   3.40   3.26
   20         52.01           3.17   3.07   7.30  38.47

   21        196.76          57.04  47.37  49.82  42.54
   22        100.48          31.83  26.46  22.60  19.59
   23         57.76          17.20  15.19  13.43  11.94
   24         37.03          10.70   9.64   8.73   7.95
   25         26.04           7.30   6.72   6.23   5.79

   26         19.84           5.42   5.09   4.80   4.54
   27         16.14           4.31   4.11   3.93   3.77
   28         13.79           3.63   3.50   3.38   3.28
   29         12.22           3.18   3.08   3.01   2.95
   30         11.12           2.88   2.81   2.74   2.69

 MONTH  SUM : 8.46157e+02
1
                                        6 HR Pest. Loads(GM), STN N:

                                        SUMMARY FOR MONTH  1986/ 5/

                                        DATA INTERVAL:   360 MINS
```

```
     1        14.54         2.63    3.50    4.44    3.97
     2        12.25         3.51    3.15    2.89    2.71
     3         9.76         2.58    2.48    2.40    2.33
     4         8.82         2.28    2.23    2.18    2.14
     5         8.19         2.10    2.06    2.03    1.99

     6        26.17         1.96    1.93    7.31   14.97
     7        66.28        18.02   17.66   16.21   14.39
     8        41.40        12.59   10.96    9.54    8.31
     9        24.20         7.25    6.36    5.61    4.97
    10        15.26         4.43    3.98    3.59    3.26

    11        10.64         2.98    2.74    2.54    2.37
    12         8.17         2.22    2.09    1.98    1.88
    13         6.75         1.80    1.72    1.65    1.58
    14         5.86         1.53    1.48    1.43    1.42
    15         5.49         1.43    1.39    1.35    1.31

    16        21.88         1.54    4.11    6.81    9.43
    17        35.99        10.15    9.60    8.63    7.61
    18        32.85         6.67    5.85    5.14   15.18
    19       281.04        34.56   78.05   94.29   74.14
    20       469.40        59.14   76.84  167.66  165.77

    21       372.24       123.73   98.89   81.54   68.07
    22       181.70        57.43   48.50   40.95   34.82
    23       109.50        32.16   30.85   25.42   21.05
    24        57.70        17.74   15.17   13.18   11.60
    25        34.16        10.20    8.98    7.94    7.05

    26        21.64         6.29    5.64    5.09    4.61
    27        14.87         4.20    3.85    3.54    3.28
    28        11.05         3.04    2.84    2.66    2.51
    29         8.79         2.37    2.25    2.14    2.04
    30         7.34         1.95    1.87    1.79    1.73

    31         6.39         1.67    1.62    1.57    1.53
 MONTH  SUM : 1.93031e+03
1
                                  6 HR Pest. Loads(GM), STN N:

                                  SUMMARY FOR MONTH  1986/ 6/

                                  DATA INTERVAL:   360 MINS

   DAY        SUM                 INTERVAL NUMBER
                               1       2       3       4

     1         5.73         1.49    1.45    1.41    1.38
     2         5.23         1.35    1.32    1.29    1.27
     3         4.83         1.24    1.22    1.20    1.18
     4         4.50         1.15    1.13    1.11    1.10
     5         4.30         1.08    1.06    1.08    1.07

     6         4.08         1.05    1.03    1.01    0.99
     7         3.76         0.97    0.95    0.93    0.92
     8         3.52         0.90    0.89    0.87    0.86
     9         3.31         0.85    0.83    0.82    0.81
    10         3.12         0.80    0.79    0.77    0.76

    11         7.79         0.75    0.74    1.13    5.17
    12      1466.78       421.40  525.89  299.55  219.96
    13       541.86       175.76  144.90  120.75  100.45
```

```
      16          112.96          24.90    21.50    21.46    45.09
      17          148.27          47.07    39.80    33.30    28.10
      18           79.88          24.24    21.33    18.44    15.88
      19           44.75          13.69    11.83    10.28     8.96
      20           26.00           7.82     6.85     6.02     5.31

      21           15.93           4.70     4.17     3.72     3.34
      22           12.21           3.00     2.72     2.47     4.02
      23           37.76           7.80     9.86    10.28     9.83
      24           47.03           9.61    12.22    12.96    12.23
      25           36.43          10.99     9.67     8.44     7.33

      26           20.97           6.37     5.54     4.83     4.22
      27           87.91           3.71     6.01    31.82    46.38
      28          132.50          41.55    35.17    29.73    26.05
      29           72.18          22.52    19.23    16.40    14.03
      30           39.17          12.06    10.39     8.97     7.76

 MONTH  SUM : 3.38419e+03
1
                                          6 HR Pest. Load(GM), STN N1

                                          SUMMARY FOR MONTH  1986/ 7/

                                          DATA INTERVAL:   360 MINS

    DAY         SUM                       INTERVAL NUMBER
                                  1        2        3        4

      1           22.20           6.73     5.86     5.12     4.49
      2           13.33           3.95     3.50     3.11     2.77
      3            8.62           2.49     2.24     2.03     1.85
      4            6.05           1.70     1.56     1.45     1.35
      5            4.58           1.26     1.18     1.11     1.04

      6            3.68           0.99     0.94     0.90     0.86
      7            3.14           0.83     0.80     0.77     0.75
      8            2.78           0.72     0.70     0.68     0.67
      9            2.52           0.65     0.64     0.62     0.61
     10            2.31           0.60     0.58     0.57     0.56

     11            2.22           0.55     0.54     0.53     0.60
     12           33.24           4.51     9.55    10.06     9.12
     13           25.59           7.90     6.90     5.85     4.95
     14           16.02           4.21     4.05     4.01     3.76
     15           11.57           3.39     3.04     2.71     2.42

     16           89.68           5.22    24.43    31.79    28.23
     17           76.41          24.35    20.46    17.13    14.67
     18          107.39          12.37    10.53     9.04    75.49
     19          463.36         208.68   115.55    78.36    60.77
     20          233.54          72.91    69 36    50.96    40.33

     21          102.30          32.92    27.25    22.83    19.31
     22           55.16          16.63    14.77    12.78    11.04
     23           31.31           9.54     8.27     7.21     6.30
     24           18.42           5.52     4.85     4.27     3.78
     25           17.98           3.35     2.99     2.67     8.96

     26          922.04         492.83   211.42   124.16    93.62
     27          232.68          75.33    62.17    51.93    43.25
     28          125.79          36.13    30.38    26.04    33.24
     29           97.58          31.58    26.13    21.66    18.20
```

```
  [illegible]
MONTH  SUM : 2.81295e+03
1
                                        6 HR Pest. Loads(GM), STN N1

                                        SUMMARY FOR MONTH  1986/ 8/

                                        DATA INTERVAL:   360 MINS

   DAY          SUM                     INTERVAL NUMBER
                               1        2        3        4

     1         17.31         5.18     4.56     4.02     3.55
     2         11.74         3.15     2.81     2.59     3.19
     3         13.56         3.61     3.56     3.35     3.05
     4          9.43         2.75     2.47     2.22     1.99
     5          6.45         1.80     1.63     1.51     1.51

     6          4.96         1.40     1.29     1.18     1.09
     7         37.81         1.35     1.48     5.93    29.05
     8        252.91        32.59    28.59    50.82   140.92
     9        300.94       102.73    80.08    64.90    53.23
    10        138.55        44.13    36.93    31.16    26.33

    11         71.21        22.26    18.91    16.16    13.89
    12         39.29        11.98    10.38     9.03     7.91
    13         23.41         7.01     6.18     5.43     4.79
    14         14.39         4.24     3.77     3.36     3.02
    15          9.48         2.72     2.47     2.24     2.05

    16          6.73         1.88     1.74     1.61     1.50
    17          5.14         1.40     1.32     1.24     1.19
    18          4.17         1.12     1.06     1.02     0.97
    19          3.53         0.93     0.90     0.86     0.84
    20          3.11         0.81     0.79     0.76     0.74

    21          2.80         0.73     0.71     0.69     0.66
    22          2.57         0.66     0.65     0.64     0.62
    23          4.24         0.61     0.61     1.27     1.76
    24          7.10         1.89     1.86     1.74     1.61
    25          5.15         1.47     1.34     1.22     1.12

    26          4.41         1.03     0.95     1.01     1.43
    27          6.53         1.75     1.72     1.60     1.46
    28          4.64         1.32     1.20     1.10     1.02
    29          3.43         0.95     0.88     0.82     0.78
    30          2.75         0.74     0.70     0.67     0.65

    31          2.38         0.62     0.60     0.58     0.57
MONTH  SUM : 1.01986e+03
1
                                        6 HR Pest. Loads(GM), STN N1

                                        SUMMARY FOR MONTH  1986/ 9/

                                        DATA INTERVAL:   360 MINS

   DAY          SUM                     INTERVAL NUMBER
                               1        2        3        4

     1          2,13         0.55     0.54     0.52     0.51
     2          1.95         0.50     0.49     0.48     0.47
     3          1.82         0.47     0.46     0.45     0.44
     4          1.71         0.44     0.43     0.42     0.42
  7        1.42       0.36   0.36   0.35   0.35
  8        1.34       0.34   0.34   0.33   0.33
  9        1.26       0.32   0.32   0.31   0.31
 10      180.15       0.30   0.69  99.64  79.52

 11      240.89      74.84  62.00  56.02  48.03
 12      195.52      59.80  53.86  44.41  37.45
 13      101.46      31.50  26.83  23.11  20.02
 14       57.18      17.29  15.03  13.22  11.64
 15       40.24      10.20   9.24  10.47  10.33

 16       29.02       8.84   7.58   6.66   5.94
 17       18.42       5.32   4.79   4.34   3.96
 18       12.79       3.61   3.31   3.05   2.82
 19        9.40       2.61   2.42   2.26   2.12
 20        8.81       2.19   2.37   2.21   2.05

 21        6.94       1.90   1.78   1.67   1.58
 22       12.36       1.51   2.51   4.18   4.16
 23       14.50       3.84   3.98   3.54   3.14
 24        9.89       2.81   2.56   2.35   2.18
 25        7.32       2.02   1.88   1.76   1.66

 26        5.89       1.56   1.48   1.45   1.39
 27        5.56       1.34   1.40   1.44   1.40
 28        5.08       1.35   1.30   1.24   1.19
 29       37.25       1.28   5.22  13.79  16.96
 30      207.44      78.43  44.58  45.48  38.94

MONTH  SUM : 1.22087e+03
:
                                  6 HR Fest. [illegible](GM), STN N1

                                  SUMMARY FOR MONTH  1986/12/

                                  DATA INTERVAL:   360 MINS

DAY        SUM                    INTERVAL NUMBER
                         1      2      3      4

  1      118.24      33.61  30.32  27.38  26.93
  2       88.47      28.66  22.75  19.55  17.51
  3       65.90      15.95  14.55  18.46  16.94
  4       54.72      14.04  12.48  15.21  12.98
  5       41.53      11.23  10.13   9.27  10.90

  6       50.69      14.13  13.51  12.10  10.95
  7       35.52      10.33   9.22   8.47   7.80
  8       31.43       7.22   7.55   8.99   7.67
  9       22.12       6.63   5.67   5.10   4.71
 10       16.12       4.40   4.14   3.90   3.68

 11       12.93       3.49   3.31   3.16   2.99
 12       10.99       2.86   2.73   2.61   2.79
 13       79.29      17.29  25.59  19.86  16.54
 14      197.56      64.58  56.60  41.24  35.15
 15      105.13      31.09  27.62  24.54  21.87

 16       67.40      19.63  17.62  15.82  14.33
 17       44.82      12.95  11.70  10.58   9.59
 18       30.76       8.75   7.99   7.31   6.69
 19       21.98       6.17   5.69   5.26   4.86
```

```
    22          [illegible]        [illegible] [illegible] [illegible] [illegible]
    23           8.33              2.23     2.13     2.03     1.95
    24           7.07              1.87     1.80     1.73     1.67
    25           6.13              1.61     1.56     1.51     1.46

    26           5.41              1.41     1.37     1.33     1.30
    27          32.55              1.26     1.74     9.87    19.69
    28          55.38             17.11    14.58    12.63    11.06
    29          33.03              9.77     8.69     7.71     6.86
    30          21.00              6.13     5.50     4.93     4.44

    31          14.01              4.02     3.65     3.32     3.03
 MONTH  SUM : 1.31751e+03
1
                                         6 HR Pest. Loads(GM), STN N1

                                         SUMMARY FOR MONTH  1986/11/

                                         DATA INTERVAL:   360 MINS

   DAY         SUM                         INTERVAL NUMBER
                                   1        2        3        4

     1          10.96              2.75     2.56     2.36     3.27
     2          18.45              5.63     4.95     4.23     3.67
     3          11.49              3.25     2.96     2.69     2.57
     4           9.93              2.36     2.73     2.31     2.53
     5           6.60              1.83     1.69     1.58     1.49

     6           5.27              1.41     1.34     1.29     1.23
     7           4.65              1.18     1.14     1.10     1.06
     8           6.24              1.06     1.67     1.88     1.63
     9           5.09              1.44     1.30     1.21     1.13
    10           4.04              1.08     1.03     0.98     0.95

    11           3.50              0.92     0.89     0.86     0.84
    12           3.26              0.83     0.84     0.81     0.78
    13           2.93              0.76     0.74     0.72     0.71
    14           2.71              0.73     0.68     0.67     0.66
    15           2.55              0.65     0.64     0.63     0.62

    16           2.39              0.61     0.60     0.59     0.58
    17           2.28              0.58     0.57     0.56     0.56
    18           2.64              0.62     0.69     0.69     0.65
    19           2.29              0.61     0.58     0.56     0.54
    20           2.04              0.53     0.51     0.50     0.50

    21           2.02              0.49     0.48     0.50     0.56
    22           2.44              0.63     0.65     0.60     0.56
    23           1.95              0.52     0.49     0.47     0.46
    24           2.02              0.45     0.50     0.55     0.52
    25           1.82              0.49     0.46     0.44     0.43

    26          82.87              0.42     5.12    22.71    54.62
    27          63.79             22.82    16.15    13.37    11.45
    28          32.81              9.91     8.65     7.58     6.67
    29          19.70              5.87     5.17     4.56     4.07
    30          12.47              3.64     3.26     2.93     2.64
 MONTH  SUM : 3.31021e+02
1
                                         6 HR Pest. Loads(GM), STN N1

                                         SUMMARY FOR MONTH  1986/12/
```

```
      DAY          SUM                       INTERVAL NUMBER
                                     1        2        3        4

        1          8.41           2.39     2.17     2.00     1.84
        2         21.20           1.69     1.55     7.76    10.20
        3         27.16           7.65     6.81     6.49     6.21
        4         17.91           5.79     4.95     3.91     3.26
        5          9.55           2.82     2.49     2.23     2.01

        6          6.42           1.83     1.67     1.53     1.41
        7          4.71           1.31     1.22     1.13     1.05
        8          3.58           0.98     0.92     0.87     0.82
        9          2.88           0.77     0.74     0.70     0.67
       10          4.99           0.81     1.16     1.46     1.57

       11          6.82           1.65     1.67     1.74     1.76
       12          7.28           1.78     1.82     1.86     1.81
       13          6.80           1.80     1.70     1.64     1.65
       14          6.87           1.64     1.61     1.74     1.87
       15          8.21           1.97     2.04     2.07     2.12

       16          9.69           2.15     2.12     2.43     2.99
       17         11.88           3.10     3.02     2.92     2.84
       18         39.14           5.14    12.79    11.31     9.90
       19         33.37           9.48     8.67     7.91     7.31
       20         24.17           6.69     6.20     5.81     5.46

       21         16.87           3.08     4.71     4.38     4.70
  MONTH  SUM : 2.79890e+02
 1
```

```
                                      6 HR Pest. Loads(GM), STN N1

                          ANNUAL DATA DISPLAY: SUMMARY FOR PERIOD ENDING 1986/12

      DAY        JAN      FEB      MAR      APR      MAY      JUN      JUL      AUG      SEP      OCT      NOV      DEC

        1      21.04    25.19    30.99    15.66    14.54     5.73    22.20    17.31     2.13   118.24    10.96     8.41
        2      30.00    24.38    49.14    15.68    12.25     5.23    13.33    11.74     1.95    88.47    18.45    21.20
        3      30.85    24.73    68.33    14.30     9.78     4.83     8.62    13.58     1.82    65.90    11.49    27.16
        4      30.72    26.40    71.90    13.52     8.82     4.50     6.05     9.43     1.71    54.72     9.93    17.91
        5      29.76    29.15    83.74    21.35     8.18     4.30     4.58     6.45     1.60    41.53     6.60     9.55

        6      29.40    28.26    87.42    24.15    26.17     4.08     3.68     4.96     1.51    50.69     5.27     6.42
        7      28.44    27.05    85.68    18.39    66.28     3.76     3.14    37.51     1.42    35.52     4.48     4.71
        8      27.54    25.43    94.57    15.30    41.40     3.52     2.78   252.91     1.34    31.43     6.24     3.58
        9      27.19    24.86    86.75    13.44    24.22     3.31     2.52   300.94     1.26    22.12     5.09     2.88
       10      27.89    24.59   216.42    17.25    15.26     3.12     2.31   138.95   180.15    16.12     4.04     4.99

       11      28.37    23.32   150.30    11.35    10.64     7.79     2.22    71.21   240.99    12.93     3.50     6.82
       12      35.22    22.54    95.42    10.65     8.17  1466.78    33.24    39.29   195.52    10.99     3.26     7.28
       13      31.18    22.03    64.41    10.15     6.75   541.86    25.99    23.42   101.46    79.29     2.93     6.80
       14      29.70    21.79    51.14     9.64     5.86   265.34    16.07    14.39    57.18   197.56     2.71     6.87
       15      26.17    18.44    43.41    14.10     5.49   146.11    11.57     9.48    43.24   105.13     2.95     8.21

       16      24.06    15.90    36.49    27.07    21.88   112.96    89.68     6.73    29.02    67.40     2.39     9.69
       17      43.93    16.58    33.56    22.95    35.99   148.27    76.41     5.14    18.42    44.82     2.28    11.88
       18      52.80    25.76    31.09    17.08    32.86    79.88   107.39     4.17    12.79    30.74     2.64    39.14
       19     156.56    87.54   129.58    13.96   201.04    44.75   463.36     3.53     9.40    21.98     2.29    33.37
       20      58.69    68.73    69.61    52.01   469.40    26.00   233.54     3.11     8.81    16.33     2.04    24.17
```

```
[illegible]
 23      37.54   36.48   30.20   57.76  109.50   37.76   31.31    4.24   14.50    8.33    1.95    0.00
 24      34.48   31.59   25.46   37.03   57.70   47.03   18.42    7.10    9.89    7.07    2.02    0.00
 25      32.96   30.03   22.54   26.04   34.16   36.43   17.98    5.15    7.32    6.13    1.82    0.00

 26      32.65   27.57   22.33   19.84   21.64   20.97  922.04    4.41    5.89    5.41   82.87    0.00
 27      31.07   24.80   29.29   16.14   14.87   87.91  232.68    6.53    5.58   32.55   63.79    0.00
 28      27.53   23.36   23.33   13.79   11.05  132.50  125.79    4.64    5.08   55.38   32.81    0.00
 29      26.02           20.18   12.22    8.79   72.18   97.58    3.43   37.25   33.03   19.70    0.00
 30      25.91           18.17   11.12    7.34   39.17   52.01    2.75  207.44   21.00   12.47    0.00
 31      25.93           16.74            6.39           29.33    2.38           14.01            0.00
0 SUM  1131.95  860.17 1872.73  846.16 1930.31 3384.17 2812.85 1019.85 1222.87 1317.51  331.02  279.89

 SUM  OF MONTHLY VALUES  1.70075e+04
```

```
b                  b
b                  b
b                  b
b bbb      oooo    b bbb
bb   b    o    o   bb   b
b     b   o    o   b     b
b     b   o    o   b     b
bb   b    o    o   bb   b
b bbb      oooo    b bbb
```

```
  CCCC      OOO    PPPPPP    Y     Y  DDDDD     EEEEEEE  M     M     OOO
 C    C    O   O   P     P   Y     Y   D    D   E        MM   MM    O   O
C         O     O  P     P    Y   Y    D     D  E        M M M M   O     O
C         O     O  P     P     Y Y     D     D  E        M  M  M   O     O
C         O     O  PPPPPP       Y      D     D  EEEEEE   M     M   O     O
C         O     O  P            Y      D     D  E        M     M   O     O
C         O     O  P            Y      D     D  E        M     M   O     O
 C    C    O   O   P            Y      D    D   E        M     M    O   O
  CCCC      OOO    P            Y     DDDDD     EEEEEEE  M     M     OOO
```

```
BBBBBB                      k
 B    B                     k
 B    B                     k
 B    B    eeee     aaaa    k   k
 BBBBB    e    e        a   k  k
 B    B   eeeeee    aaaaa   k k
 B    B   e        a     a  kk k
 B    B   e    e   a    aa  k   k
BBBBBB     eeee     aaaa a  k    k
```

```
Job:  COPYDEMO
Date: Wed Jun  3 14:19:39 1987
```

```
RUN
GLOBAL
  COPY SEQUENTIAL FILE TO THE  1986 HSPF-TSS
  <--BX--><--START-DATE/TIME-  *** ----END-DATE/TIME-->
  START       1986/01/01  0:00  END    1986/12/31 24:00
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1 TSSFL    15
END GLOBAL
*** operation sequence - this block specifies that a one hour timestep
*** is used and six copy operations will be performed.
OPN SEQUENCE
    <--------19X-------->  ***  <IDT>
    INGRP              INDELT  1:00
***   <OPTYP AND #>
      COPY         1
      COPY         2
      COPY         3
      COPY         4
      COPY         5
      COPY         6
    END INGRP
END OPN SEQUENCE
*** copy operation - this specifies that operations 1 thru 6 contain a
*** single mean-valued time series.
COPY
  TIMESERIES
  copy-opn ***
    # -  #  NPT  NMN ***
    1    6         1
  END TIMESERIES
END COPY
*** external sources - this block directs the data from the sequential files
*** (fort.41 to fort.46) to be input time series for the six copy operations
EXT SOURCES
<-volume-> <member> SsysSgap<--mult-->Tran <-target vols> <-grp> <-member->  ***
<name>   # <name> # tem strg<-factor->strg <name>   #   #        <name> # #  ***
SEQ     41 HYDHR    METRZERO              COPY     1     INPUT  MEAN
SEQ     42 HYDHR    METRZERO              COPY     2     INPUT  MEAN
SEQ     43 HYDHR    METRZERO              COPY     3     INPUT  MEAN
SEQ     44 HYDHR    METRZERO              COPY     4     INPUT  MEAN
SEQ     45 HYDHR    METRZERO              COPY     5     INPUT  MEAN
SEQ     46 HYDHR    METRZERO              COPY     6     INPUT  MEAN
END EXT SOURCES
*** external targets - this block directs the time series from the six copy
*** operations to be saved on the TSS as the indicated data sets
EXT TARGETS
<-volume-> <-grp> <-member-><--mult-->Tran <-volume-> <member> Tsys Tgap Amd ***
<name>   #        <name> # #<-factor->strg <name>   # <name>    tem strg strg***
COPY     1 OUTPUT MEAN                     TSS     11 PRETB1   METR      ADD
COPY     2 OUTPUT MEAN                     TSS     12 PRETB2   METR      ADD
COPY     3 OUTPUT MEAN                     TSS     13 PRETB3   METR      ADD
COPY     4 OUTPUT MEAN                     TSS     14 HRWIND   METR      ADD
COPY     5 OUTPUT MEAN                     TSS     15 HRSOLR   METR      ADD
COPY     6 OUTPUT MEAN                     TSS     16 HRATMP   METR      ADD
END EXT TARGETS
END RUN
```

```
b                  b
b                  b
b                  b
b bbb     oooo     b bbb
bb   b   o    o    bb   b
b    b   o    o    b    b
b    b   o    o    b    b
bb   b   o    o    bb   b
b bbb     oooo     b bbb


PPPPPP   L          OOO     TTTTTTT    GGGG   EEEEEEE  N     N  DDDDD    EEEEEEE  M     M    OOO
P    P   L         O   O       T      G    G  E        NN    N  D    D   E        MM   MM   O   O
P    P   L        O     O      T     G        E        N N   N  D     D  E        M M M M  O     O
P    P   L        O     O      T     G        E        N  N  N  D     D  E        M  M  M  O     O
PPPPPP   L        O     O      T     G        EEEEEE   N   N N  D     D  EEEEEE   M     M  O     O
P        L        O     O      T     G  GGGG  E        N    NN  D     D  E        M     M  O     O
P        L        O     O      T     G     G  E        N     N  D     D  E        M     M  O     O
P        L         O   O       T      G    G  E        N     N  D    D   E        M     M   O   O
P        LLLLLLL    OOO        T       GGGG   EEEEEEE  N     N  DDDDD    EEEEEEE  M     M    OOO


BBBBBB                        k
 B    B                       k
 B    B                       k
 B    B   eeee     aaaa       k   k
 BBBBB   e    e        a      k  k
 B    B  eeeeee    aaaaa      k k
 B    B  e        a    a      kk k
 B    B  e    e   a   aa      k   k
BBBBBB    eeee     aaaa a     k    k


                    Job:  PLOTGENDEMO
                    Date: Wed Jun  3 14:09:56 1987
```

```
RUN
GLOBAL
  DEMONSTRATION PLOT INPUT
  <--8X--><--START-DATE/TIME-> *** <---END-DATE/TIME-->
  START       1986/01/01  0:00  END    1986/12/31 24:00
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1 TSSFL    15
END GLOBAL
*** operation sequence - this block specifies that an hourly timestep
*** is used and one plotting operations will be performed.
OPN SEQUENCE
    <--------19X-------->  ***  <IDT>
    INGRP               INDELT  1:00
      <OPTYP AND ##> ***
      PLTGEN       1
    END INGRP
END OPN SEQUENCE
PLTGEN
  PLOTINFO
    # - # file  npt  nmn labl  pyr pivl ***
    1       51         2        12   24
  END PLOTINFO
  GEN-LABELS
*** # -  #<--------------------title-------------->           <------ylabel------>
    1     Streamflow vs Rain-Snow 1986                         Mm3 or cm/day
  END GEN-LABELS
  SCALING
    # - #       ymin      ymax      ivlin ***
    1                      1.5       10.
  END SCALING
  CURV-DATA
    # - #    <---label------>  line intg  col tran ***
    1         Streamflow N1                1
  END CURV-DATA
  CURV-DATA
    # - #    <---label------> line intg  col tran ***
    1         Precipitation                2
  END CURV-DATA
END PLTGEN
*** external sources - this block directs the data from the a TSS data set
*** to be an input time series for the plotgen operations.  The subscript
*** after 'MEAN ' indicates the order in which the time series will be
*** placed within the plot file.
EXT SOURCES
<-volume-> <member> SsysSgap<--mult-->Tran <-target vols> <-grp> <-member->  ***
<name>   # <name> # tem strg<-factor->strg <name>   #   #         <name> # #  ***
TSS    201 OFLWN1   METR      .0036          PLTGEN   1     INPUT  MEAN   1
TSS     11 PRETB1   METR      .01            PLTGEN   1     INPUT  MEAN   2
END EXT SOURCES
END RUN
```

```
b                b
b                b
b                b
b bbb    oooo    b bbb
bb   b  o    o   bb   b
b     b o    o   b     b
b     b o    o   b     b
bb   b  o    o   bb   b
b bbb    oooo    b bbb



DDDDD    U     U RRRRRR     AAA    N     N L          1
 D   D   U     U R     R   A   A   NN    N L         11
 D    D  U     U R     R  A     A  N N   N L        1 1
 D    D  U     U R     R  A     A  N  N  N L          1
 D    D  U     U RRRRRR   AAAAAAA  N   N N L          1
 D    D  U     U R  R     A     A  N    NN L          1
 D    D  U     U R   R    A     A  N     N L          1
 D   D   U     U R    R   A     A  N     N L          1
DDDDD     UUUUU  R     R  A     A  N     N LLLLLLL   11111



BBBBBB                     k
 B    B                    k
 B    B                    k
 B    B   eeee     aaaa    k   k
 BBBBB   e    e        a   k  k
 B    B  eeeeee    aaaaa   k k
 B    B  e        a     a  kk k
 B    B  e    e   a    aa  k   k
BBBBBB    eeee     aaaa a  k    k




                                     Job:  DURANL1
                                     Date: Fri Jun 26 10:12:17 1987
```

```
     1986/ 5/23 19: 0     LC CURVE # 1    # INTERVALS    81    CONC LEVEL  2.500
     1986/ 5/26  8: 0     LC CURVE # 1    # INTERVALS   237    CONC LEVEL  1.000
     1986/ 6/12 10: 0     LC CURVE # 1    # INTERVALS     7    CONC LEVEL  25.00
     1986/ 6/14 22: 0     LC CURVE # 1    # INTERVALS    67    CONC LEVEL  12.50
     1986/ 6/20 14: 0     LC CURVE # 1    # INTERVALS   209    CONC LEVEL  2.500
     1986/ 6/26  9: 0     LC CURVE # 1    # INTERVALS    80    CONC LEVEL  2.500
     1986/ 7/ 1 12: 0     LC CURVE # 1    # INTERVALS    97    CONC LEVEL  2.500
     1986/ 7/ 3 19: 0     LC CURVE # 1    # INTERVALS   529    CONC LEVEL  1.000
     1986/ 7/14  1: 0     LC CURVE # 1    # INTERVALS    46    CONC LEVEL  2.500
     1986/ 7/19  5: 0     LC CURVE # 1    # INTERVALS     6    CONC LEVEL  12.50
     1986/ 7/23 20: 0     LC CURVE # 1    # INTERVALS   183    CONC LEVEL  2.500
     1986/ 7/31 16: 0     LC CURVE # 1    # INTERVALS   136    CONC LEVEL  2.500
     1986/ 8/ 4 15: 0     LC CURVE # 1    # INTERVALS   566    CONC LEVEL  1.000
     1986/ 8/12  5: 0     LC CURVE # 1    # INTERVALS   108    CONC LEVEL  2.500
     1986/ 8/14 15: 0     LC CURVE # 1    # INTERVALS   168    CONC LEVEL  1.000
     1986/ 9/16 14: 0     LC CURVE # 1    # INTERVALS   145    CONC LEVEL  1.000
1

 DURATION ANALYSIS OPERATION NO.     1

 Pred Pesticide Conc (ug/l) Stn N1

 START DATE: 1985/12/31 24: 0  END DATE: 1986/12/21 24: 0

 ANALYSIS SEASON STARTS:  2/28 24: 0  ENDS: 11/30 24: 0
1


 FRACTION OF TIME SPENT IN EXCURSIONS AT EACH LEVEL WITH DURATION >= THE SPECIFIED DURATIONS
 FRACTION IS RELATIVE TO TOTAL TIME SPAN


 POSITIVE EXCURSIONS

                    DURATIONS
                  1           6          24          96
LEVELS
 0.5000      0.6817      0.6811      0.6811      0.6394
  1.000      0.2839      0.2827      0.2818      0.2492
  10.00      0.1530e-01 0.1530e-01 0.1288e-01     0.


 NEGATIVE EXCURSIONS

                    DURATIONS
                  1           6          24          96
LEVELS
 0.5000      0.3183      0.3183      0.3097      0.2758
  1.000      0.7161      0.7161      0.7133      0.6986
  10.00      0.9847      0.9847      0.9847      0.9847


 UNDEFINED EVENTS (NO WATER)

                    DURATIONS
                  1           6          24          96
             0.          0.          0.          0.
1
```

```
FRACTION IS RELATIVE TO THE TIME SPENT IN EXCURSIONS AT EACH LEVEL


POSITIVE EXCURSIONS

                      DURATIONS
                     1          6         24        96
LEVELS
 0.5000      1.000     0.9991     0.9991     0.9380
  1.000      1.000     0.9957     0.9925     0.8778
  10.00      1.000      1.000     0.8416         0.


NEGATIVE EXCURSIONS

                      DURATIONS
                     1          6         24        96
LEVELS
 0.5000      1.000      1.000     0.9729     0.8663
  1.000      1.000      1.000     0.9962     0.9757
  10.00      1.000      1.000      1.000      1.000


UNDEFINED EVENTS (NO WATER)

                      DURATIONS
                     1          6         24        96
                0.         0.         0.         0.
1

TIME SPENT IN EXCURSIONS AT EACH LEVEL WITH DURATION >= THE SPECIFIED DURATIONS


POSITIVE EXCURSIONS

                      DURATIONS
                     1          6         24        96
LEVELS
 0.5000      4499.      4495.      4495.      4220.
  1.000      1874.      1866.      1860.      1645.
  10.00      101.0      101.0      85.00         0.


NEGATIVE EXCURSIONS

                      DURATIONS
                     1          6         24        96
LEVELS
 0.5000      2101.      2101.      2044.      1820.
  1.000      4726.      4726.      4708.      4611.
  10.00      6499.      6499.      6499.      6499.


UNDEFINED EVENTS (NO WATER)
```

```
                  0.          0.          0.          0.
1

 STANDARD DEVIATION OF DURATION OF EXCURSIONS AT EACH LEVEL GIVEN THAT THE DURATION >= THE SPECIFIED DURATIONS


 POSITIVE EXCURSIONS

                        DURATIONS
                      1           6          24          96
 LEVELS
  0.5000      332.7       334.6       334.6       309.8
   1.000      188.5       192.6       192.8       181.3
   10.00      36.31       36.31          0.          0.


 NEGATIVE EXCURSIONS

                        DURATIONS
                      1           6          24          96
 LEVELS
  0.5000      163.2       163.2       168.7       171.3
   1.000      363.4       363.4       363.7       360.9
   10.00      1185.       1185.       1185.       1185.


 UNDEFINED EVENTS (NO WATER)

                        DURATIONS
                      1           6          24          96
                  0.          0.          0.          0.
1

    SUMMARY

    TOTAL LENGTH OF DEFINED EVENTS:        6600. INTERVALS

    TOTAL LENGTH OF UNDEFINED EVENTS:         0. INTERVALS

    TOTAL LENGTH OF ANALYSIS:     275.00 DAYS

    SAMPLE SIZE:     6600

    SAMPLE MAXIMUM:  44.68

    SAMPLE MINIMUM: 0.1335

    SAMPLE MEAN:  1.457

    SAMPLE STANDARD DEVIATION:  2.528


   GLOBAL EXCEEDANCE SUMMARY

    CURVE NUMBER   FRACTION EXCEEDED
```

```
RUN
GLOBAL
  CONDUCT A DEMONSTRATION DURATION ANALYSIS ON PESTICIDE DATA
  (--BX-->(--START-DATE/TIME-> *** (---END-DATE/TIME-->
  START       1986/01/01  0:00  END    1986/12/21 24:00
  RUN INTERP OUTPUT LEVEL    3
  RESUME     0 RUN     1 TSSFL    15
END GLOBAL
*** operation sequence - this block specifies that an hourly timestep
*** is used and one duration analysis will be performed.
OPN SEQUENCE
    <---------19X---------> ***  <IDT>
    INGRP               INDELT  1:00
      <OPTYP AND ##> ***
      DURANL       1
    END INGRP
END OPN SEQUENCE
DURANL
  GEN-DURDATA
    # -  #<***--------------title-----------------------> NDUR NLEV PRFG   P- LCNU LCOU
         ***                                                                 UNIT
    1     Pred Pesticide Conc (ug/l) Stn M1                4    3    6   51    1    1
  END GEN-DURDATA
  SEASON
*** # -  #         <---start--->         <----end---->
    1               03                    11
  END SEASON
  DURATIONS
    # -  ####<---Durations--------->
         *** 1    2    3    4    5
    1        1    6   24   96    0
  END DURATIONS
  LEVELS
    # -  #### 1    2    3    4    5    6    7
    1     0.50  1.0 10.0
  END LEVELS
  LCONC
    # -  ####    LC1        LC2        LC3        LC4        LC5        LC6        LC7
    1           25.0       12.5        2.5        1.0
  END LCONC
END DURANL
*** external sources - this block directs the data from the a TSS data set
*** to be an input time series for the DURANL operations.  The subscript
*** after 'MEAN ' indicates the order in which the time series will be
*** placed within the plot file.
EXT SOURCES
<-volume-> <member> SsysSgap<--mult-->Tran <-target vols> <-grp> <-member->  ***
<name>   # <name> # tem strg<-factor->strg <name>   #  #         <name> # #  ***
TSS    301 OUTPT1   METR                   DURANL   1     INPUT          1
END EXT SOURCES
END RUN
```

```
 NUMBER OF EXCURSIONS AT EACH LEVEL WITH DURATION  >= THE SPECIFIED DURATIONS


 POSITIVE EXCURSIONS

                          DURATIONS
                        1            6            24           96
 LEVELS
  0.5000       15.00        13.00        13.00        8.000
   1.000       12.00        10.00        9.000        5.000
   10.00       3.000        3.000        1.000           0.


 NEGATIVE EXCURSIONS

                          DURATIONS
                        1            6            24           96
 LEVELS
  0.5000       15.00        15.00        11.00        7.000
   1.000       13.00        13.00        12.00        10.00
   10.00       4.000        4.000        4.000        4.000


 UNDEFINED EVENTS (NO WATER)

                          DURATIONS
                        1            6            24           96
                  0.           0.           0.           0.
1


 AVERAGE DURATION OF EXCURSIONS AT EACH LEVEL GIVEN THAT THE DURATION >= THE SPECIFIED DURATIONS


 POSITIVE EXCURSIONS

                          DURATIONS
                        1            6            24           96
 LEVELS
  0.5000       299.9        345.8        345.8        527.5
   1.000       156.2        186.6        206.7        329.0
   10.00       33.67        33.67        65.00           0.


 NEGATIVE EXCURSIONS

                          DURATIONS
                        1            6            24           96
 LEVELS
  0.5000       140.1        140.1        185.8        240.0
   1.000       363.5        363.5        392.3        441.1
   10.00       1625.        1625.        1625.        1625.


 UNDEFINED EVENTS (NO WATER)
```

APPENDIX I

QUALITY ASSURANCE TESTING

Quality Assurance Testing

In order to ensure that sampling equipment and handling methods were not causing contamination or undue decay of atrazine samples, three tests were undertaken early in the study in 1985. The purpose, methods and results of these tests follow.

Test #1

Purpose: To determine the likelihood and degree of cross contamination of open atrazine water samples within the collection carousel of an ISCO 2100 automatic sequential sampler.

Method: Duplicate sampler bottles were filled with organic free water and placed in the 24 polypropylene bottle collection carousel of an ISCO 2100 sampler. The bottles were placed in the carousel along with 22 empty bottles and were left in place throughout one full sampler cycle which lasted 48 hours. The duplicate organic free water aliquots were submitted in standard acid washed glass bottles for atrazine analysis to the OMAF pesticide laboratory.

Results: Both samples were reported to have non-detectable levels of atrazine and d-ethyl atrazine.

Conclusion: There is no significant cross contamination in a static mode in the sampler.

Test #2

Purpose: To determine the rate of decay of unpreserved atrazine in water samples at room temperature.

Method: A standard solution of atrazine was prepared in the laboratory using a common agricultural grade atrazine mixture in Nissouri Creek water. An aliquot of this solution was preserved with dichloromethane at time = 0 hours. Duplicate aliquots were placed in ISCO polypropylene bottles and left in an ISCO sampler at room temperature for 72 hours. These samples were then preserved with dichloromethane. All samples were submitted for atrazine analysis in standard acid washed glass bottles to the OMAF pesticides laboratory.

Results: The sample which was immediately preserved had an atrazine concentration of 12 ug/L of atrazine and no detectable d-ethyl atrazine.

The samples which were preserved after 72 hours had atrazine concentrations of 11 ug/L and 7.9 ug/L and no detectable d-ethyl atrazine. The average apparent decay rate was 2.55 ug/L over 72 hours or about 5% per day. Dr. B. Ripley (OMAF pesticide laboratory) indicated that the dichloromethane preservative can interfere with the atrazine determination and therefore some of the apparent decay could be due to the preservative.

Action Taken: In order to reduce interference and decay, all samples were kept refrigerated after collection and delivered to the OMAF pesticide laboratory within 48 hours of collection in an unpreserved state. It is believed that atrazine decay would be limited to less than 10% using this procedure.

Test #3

Purpose: To determine the incidence and degree of cross contamination in the ISCO 2100 sample delivery system.

Method: An ISCO 2100 sampler delivery system was flushed with organic free water for several minutes. A standard atrazine solution was prepared using an agricultural grade atrazine mixture in Nissouri Creek water. Duplicate samples of the atrazine solution were taken and preserved with dichloromethane. Twenty litres of the atrazine solution was pumped through the sampler. Duplicate pumped samples were taken at the halfway point and again at the end of the pumping and preserved with dichloromethane. The sampler was left for 24 hours and then two litres of organic free water was pumped through the sampier into glass sample bottles and preserved with dichloromethane. All samples were submitted in standard acid washed glass bottles to the OMAF pesticides laboratory for atrazine analysis.

Results: The original duplicate atrazine solution samples had atrazine concentrations of 14 ug/L and no detectable d-ethyl atrazine. The four pumped atrazine samples all had atrazine concentrations of 12 ug/L and no detectable d-ethyl atrazine. The pumped organic free water had no detectable atrazine or d-ethyl atrazine.

Conclusion: There is no significant carry over of atrazine within the sampler delivery system.